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Neutron Generator Production Mission in a National Laboratory

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ABSTRACT

In the late 1980's the Department of Energy (DOE) faced a future budget shortfall. By the spring of 1991, the DOE had decided to manage this problem by closing three production plants and moving production capabilities to other existing DOE sites. As part of these closings, the mission assignment for fabrication of War Reserve (WR) neutron generators (NGs) was transferred from the Pinellas Plant (PP) in Florida to Sandia National Laboratories, New Mexico (SNL/NM). The DOE directive called for the last WR NG to be fabricated at the PP before the end of September 1994 and the first WR NG to be in bonded stores at SNL/NM by October 1999.

Sandia National Laboratories successfully managed three significant changes to project scope and schedule and completed their portion of the Reconfiguration Project on time and within budget. The PP was closed in October 1995. War Reserve NGs produced at SNL/NM were in bonded stores by October 1999. The costs of the move were recovered in just less than five years of NG production at SNL/NM, and the annual savings today (in 1995 dollars) is $47 million.

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ACRONYMS

CDR: Conceptual Design Report
COTS: Commercial Off-The-Shelf
EA: Environmental Assessment
EIS: Environmental Impact Statement
ES&H: Environment, Safety and Health
ESP: Employee Safety Program
ESSP: Employee Safety Security Program
DOE: Department of Energy
GPP: General Plant Project
MTC: Metal Trades Council
MOU: Memorandum of Understanding
MVS: Material Value Stream
NEPA: National Environment Policy Act
NG: Neutron Generator
NNSA: National Nuclear Security Administration
NT: Neutron Tube
NWC: Nuclear Weapons Complex
ORR: Operational Readiness Report
PMAA: Purchased Material Acceptance Application
PP: Pinellas Plant
RA: Readiness Assessment
SA: Safety Assessment
SNL: Sandia National Laboratories
SNL/CA: Sandia National Laboratories, California
SNL/NM: Sandia National Laboratories, New Mexico
WR: War Reserve
6S: Sort, Straighten, Shine, Standardize, Sustain, and Safety

TABLE OF CONTENTS

ABSTRACT **3**

ACKNOWLEDGMENTS **4**

ACRONYMS **5**

TABLE OF CONTENTS **7**

EXECUTIVE SUMMARY **11**

Problem *11*
Evaluation 11
Down Selection 11
Decision 12
Scope of This Report 12

Reconfiguration Project *12*
Initial Schedule 13
Changes to the Project 13

Lessons Learned *15*

Results *16*
Product 16
Cost Savings 16
Processes 17

PREFACE **19**

Introduction *19*

Historical Perspective *19*

Timeline *20*

PRE-PINELLAS PLANT CLOSURE **23**

Initial Walk through *23*

Target Loading at LANL *23*

Management Structure *24*

Capabilities/Requirements *24*

Conceptual Design Reports *25*

Activity Transfer Plan *26*
Equipment Transfer Paradigm 26
Disconnection and Reconnection Process 27
Equipment Procurement 28
Critical Skills 28

START-UP ACTIVITIES AT SANDIA NATIONAL LABORATORIES **31**

Neutron Tube Prototyping in East Annex *31*

Compliance to Regulatory Requirements ... 32
Design and Value Engineering of Building 870 ... 32
Construction of Building 870 ... 33
Equipment Installation ... 35
Readiness Assessment ... 36
Production Trades Program ... 37
Piece Part Procurement ... 38
Infrastructure Support at Sandia National Laboratories ... 38
Analytical Testing Capability ... 39
Process Qualification and Prove-in ... 40
Collocation of ES&H Subject Matter Experts ... 41
Facility/Equipment Maintenance ... 41
Information Technologies ... 42
Production/Development Use Same Equipment on Same Floor Space ... 43
Production Staging Space ... 44

SUBSEQUENT IMPROVEMENTS ... 45
Rapid Reactivation ... 45
Memorandums of Understanding ... 47
Burning Platform ... 47
Selection and Implementation of Lean/Six Sigma ... 48
Information Technologies ... 49
Materials Management ... 50
Introduction ... 50
Integration with Procurement ... 51
Value Stream Mapping ... 51
Standards and Discipline ... 51
Supplier Metrics ... 52
Reduction of Inspection Waste for Incoming Materials ... 52
Supplier Conference ... 53
Upfront Drawing Reviews ... 54
New Production Warehouse ... 54
Conclusions ... 55

ESTABLISHING A CULTURE ... 57
Background ... 57
Conflicts ... 58
Separate Development/Production Equipment and Space ... 58
Approach to Quality ... 58
Collocation ... 59
Utilization of Laboratory Capabilities ... 59
Captive Facility Maintenance and Repair Contractor ... 59
Design/Production Interface ... 60

Command Media Evolution 60
Infrastructure Implementation 61
Lean/Six Sigma 62
Employee Safety Security Program 62

LESSONS LEARNED 65
Production Capacity 65
Compliance to Regulations 65
Compliance-based Oversight 65
Readiness Assessment 66
Development on Production Floor 67
Design/Production Relationship Affected by Collocation 68
Cost Comparisons 68
Unused Production Floor Space 69
Facility Construction 69
Line Representative 69
Regulatory Requirements 69
Building Capability 70
Design Evaluations 70
Funding and Timing of Funding 70
Chilled and Frozen Design 71
Building Modifications on the Production Floor 71
Legacy Testers and Stored Electronic Media 71
Culture 72
Information Technologies 72
Project Management 73
Organization Issues 73
Knowledge and Experience Are Valued 73
Roles and Responsibilities 74
Organization Structure 74
Flow Charting 74
Production Command Media Hierarchy 75

CONCLUSIONS 77

APPENDIX A: DETAILED TIMELINE 79

APPENDIX B: PROJECT/PROGRAM LEADERSHIP PRINCIPLES 87
Project/Program Concepts 87

EXECUTIVE SUMMARY

Problem

In the late 1980s it was apparent that the budget for the Nuclear Weapons Complex (NWC) needed to shrink, or at a minimum the budget would not grow at the rate of inflation. The number of weapons in the stockpile was decreasing and new weapon design was on hold. The challenge was to find a way to reduce the NWC budget without loss of capability or decreased quality of product.

The Department of Energy (DOE) led a committee to evaluate options. Two primary options were considered: The NWC could downsize in place or production plants could be closed. The DOE-led committee concluded that sufficient cost savings would be realized only if production plants were closed. A preliminary decision was made to evaluate the closure of the Pinellas Plant (PP) in Florida, the Mound Plant in Ohio, and the Rocky Flats Plant in Colorado. Potential sites within the NWC were identified to which production activities could be moved. When these plans were implemented it became known as the Reconfiguration Project.

Evaluation

Sandia National Laboratories, New Mexico (SNL/NM) and other potential receiving sites were asked to evaluate the possibility of moving production activities to them. Could production of neutron tubes and neutron generators be moved to SNL/NM and would SNL/NM be willing to accept the mission assignment for War Reserve production of neutron generators?

A cross-cutting team from SNL/NM walked the production floor space at the PP in June 1991. Production floor space, production equipment, and fabrication processes utilized at the PP plant were examined. This team identified capabilities that would be transferred, capabilities that would be outsourced to private industry and capabilities that were already in place at SNL/NM. Sandia National Laboratories communicated to DOE a willingness to accept the mission assignment to fabricate War Reserve neutron generators, if DOE chose to give them the assignment.

Down Selection

December 1991, DOE announced the preferred sites to which production would be moved from the three plants that would be closed. Sandia National Laboratories would take the lead to evaluate options for production of War Reserve neutron tubes and neutron generators. Ultimately, three possibilities were examined: (1) a stand-alone facility at SNL/NM which could be managed by a production contractor, (2) production integrated with existing infrastructure at Kansas City, and (3) production integrated with existing infrastructure at SNL/NM but with the stipulation that existing facilities would be used. Sandia National Laboratories prepared a Conceptual Design Report for the first and third option and supported Kansas City as they prepared a conceptual Design Report for the second option.

Decision

The DOE selected the third option for implementation: production of War Reserve neutron tubes and neutron generators would be moved from the PP to SNL/NM. The deciding factor was reduction in risk, because design of neutron tubes and neutron generators already existed at SNL/NM. Further, SNL/NM also had the capability to prototype neutron tubes. The stand-alone facility was too expensive and would not have reduced overall production costs within the NWC. Production of neutron generators at the Kansas City Plant and at SNL/NM were comparable in cost.

Scope of This Report

This report is restricted to the transfer of War Reserve production of neutron tubes and neutron generators from the PP to SNL/NM and does not address other production mission assignment changes within the NWC. Historical aspects are described, development of production at SNL/NM is considered, and lessons learned are provided to assist others who might have a similar responsibility in the future.

The report also addresses issues associated with the very aggressive and proactive schedule. Production ceased at the PP before production capability existed at SNL/NM. Equipment was shipped and stored for six to eighteen months before installation at Sandia National Laboratories. Construction of new space, purchase of new equipment, compliance to regulatory requirements, qualification of production processes, and product acceptance occurred for product never produced at the PP as War Reserve product.

Reconfiguration Project

The Reconfiguration Project was a bold move by the Department of Energy to reduce costs to the NWC without loss of capability or decreased quality of product in the stockpile. Elimination of duplicative infrastructure was an essential part of the cost savings. Cost avoidance contributed. For example, had production of neutron generators remained at the PP, the PP facilities would have incurred significant costs to upgrade to nuclear facilities. The overall Reconfiguration Project was managed by DOE because it affected the closure of three production plants and receiver sites for production activities. Sandia National Laboratories was responsible for the transfer of production of War Reserve neutron tubes and generators to SNL/NM.

The design capacity provided by DOE for production of neutron generators at SNL/NM was 600 units a year, which included both development and production units. Existing infrastructure at SNL/NM would be used to the maximum. To reduce costs, production and development would use the same equipment and the same floor space. Tritium loading of neutron tube targets would occur at Los Alamos National Laboratory to avoid construction of a nuclear facility at SNL/NM. Conceptual design reports would be used to assist DOE in making final decisions relative to plant closures and movement of War Reserve production mission assignments.

Initial Schedule

In January 1992, the Reconfiguration Project forecast that the PP would stop production of War Reserve neutron generators at the end of October 1995, with War Reserve product being in bonded stores at SNL/NM at the end of October 2000. After production ceased at the PP, equipment would be moved to SNL/NM. Facilities at SNL/NM would be available in January 1996, so equipment could move directly from the PP to the new production space at SNL/NM. The PP would formally close its doors at the end of October 1996. This schedule was driven by the needs of the nuclear weapons stockpile; there was a reduced need for new and replacement neutron generators which provided the window to move production activities.

Changes to the Project

Schedule Compression

In the spring of 1992, while Conceptual Design Reports were being prepared, a more careful examination of neutron generator delivery requirements indicated the PP could be closed one year earlier without negative consequences to the stockpile. A significant cost savings (approximately $100 million) would occur through closing the PP one year earlier. The Reconfiguration Project was pulled up, but the length of the project was not changed. Hence, War Reserve neutron generators would need to be in bonded stores at SNL/NM by the end of October 1999, even though delivery schedules would be met with the initial schedule of October 2000.

Impact: This schedule change had significant impact on the project. Equipment would be disconnected and shipped to SNL/NM before the new building existed. Storage of equipment for 6 to 18 months would be required. Analytical capability at the PP would cease before similar capabilities would exist at SNL/NM. Hence, there would be no cross checking of analyses between the two locations.

Actions Taken: Building 882 was identified at SNL/NM which could be used to store equipment transferred from the PP. An equipment transfer paradigm was developed to assure equipment would not be transferred that did not have a forecast life beyond 2003. Equipment was characterized before it was disconnected to provide a baseline for operation at SNL/NM. Standards were developed for analyses that were measured at the PP before closure and at SNL/NM after start-up.

Delay in Reconfiguration Decision:

In November 1993 a new President of the United States was elected, and from a different political party. The decision date to implement the Reconfiguration Project was delayed almost a year; the project was put into a continuation mode. This delay required adjustment in the design and construction phase of Building 870, if the new production space would be available in January 2006 as required by the aggressive schedule.

Impact: This delay mostly affected the design and construction of Building 870. Standard times for design and construction no longer supported the aggressive Reconfiguration Project schedule. A

Continuing Resolution in Congress could delay the beginning of construction for an unknown length of time with drastic impact on the project. Though this decision to delay implementation of the Reconfiguration Project allowed a refinement of the Conceptual Design Report, it took one year out of the center of the project timeline making equipment installation, process qualification and production of War Reserve units much more time constrained.

Actions Taken: The standard design/construction approach for new buildings was shortened by about 6 months. The procurement package for construction was prepared during the end of the design phase. The contractor was required to start construction prior to the end of the fiscal year 1994 to assure a Continuing Resolution would not delay the project. Prototyping of neutron tubes, with new production compatible equipment, was established in the East Annex of Building 870. Negotiations occurred with other organization within SNL/NM to start activities in parallel rather than complete them in series. The Readiness Assessment (RA) process was changed to a staged process so neutron tube fabrication could commence while neutron generator equipment installation was still in progress.

Capacity Increase

The capacity requirement, to fabricate 600 neutron generators at SNL/NM, was sufficient to support the Active Stockpile but not the Inactive Stockpile. Also, this capacity would not fully meet development needs. Depending on the model, the actual capacity of production at Sandia National Laboratories needed to be two to three times the initial design number. The Reconfiguration Project became aware of the capacity shortfall after Building 870 had been designed and was under construction. Hence, in the middle of the Reconfiguration Project, plans were developed and implemented to increase the capacity of production at Sandia National Laboratories to about 1500 neutron generators a year. The capacity increase had to be realized without any down time to War Reserve fabrication of neutron tubes or neutron generators.

Impact: Building 870 was designed with minimal space to meet a capacity of 600 units a year. There was no free space. A capacity of 1500 units a year could not be met with existing equipment, even with multiple work shifts. The building infrastructure in the neutron generator space would require a major modification to achieve the higher capacity, resulting in a down time of about 6 months. Without free space, modifications could not be made in the neutron tube production line to add additional equipment. Increasing the capacity was an added effort and strained the Reconfiguration Project, which already had severe time constraints.

Actions Taken: A Rapid Reactivation Project was initiated to address the capacity issue. Some production activities (cleaning and plating) were moved from the East Annex of Building 870 to Building 700 to create space that could be modified in the East Annex. When modifications were completed in the freed-up space, other operations were moved into that space to create the next area to be modified. A new wing was designed and construction on Building 857 for neutron generator fabrication. Production was moved to this new wing in Building 875 without a shut down in the fabrication capability of neutron generators and without negative impact to the qualification of a new neutron generator. Methods were developed to perform facility modification adjacent to production operations that where sensitive to particulate generation, and this was accomplished without a decrease in yields or reduction in quality of product.

Critical Skills

In the fall of 1993 while Building 870 was in design, required critical skills to fabricate War Reserve neutron tubes and generators at the PP were identified. These same skills would be required at SNL/NM, and personnel could be transferred from the PP to meet those needs. The list of critical skills contained management, technical staff and technologists. Floor operators would not be transferred. Production operators would be developed and trained at SNL/NM. Job descriptions were written, interested PP personnel were interviewed in the spring of 1994, and those most qualified were offered transfers to SNL/NM. A total of 83 individuals were transferred to SNL/NM as part of the Reconfiguration Project. The first PP employees arrived at SNL/NM in July 1994 with the bulk of the transfers occurring after the PP closed at the end of October 1995.

The bulk of the PP employees would move to SNL/NM before construction of Building 870 was completed, and there was insufficient office space in Building 870 to house all of the PP employees. Four mobile trailers were moved close to Building 870 to partially address the office space shortfall. Building 879 was constructed, with an emphasis on teaming, to address the balance of the office space needs.

Lessons Learned

Several high level lessons were learned through the successful completion of the Reconfiguration Project that moved production of War Reserve neutron tubes and generators to SNL/NM. First, one must manage to the mission. As requirements change which impact schedule and scope of a project, as they will in any large multi-year project, focus on what is really crucial to successfully accomplishing the mission. Do not allow second order effects to dominate the response to the changes.

Second, challenge current practices. An impossible schedule is an opportunity to explore different ways to do things. In the current project two examples are significant. The compressed schedule led to the development of different approaches for completing design and occupancy. Having the design and procurement flow continuously from the beginning to the end without a hiatus in time for evaluation of 50% and 100% design milestones dramatically shortens the design time, while maintaining momentum and continuity throughout the design. A staged RA is more efficient and has a higher quality of assessment in comparison to an assessment after all equipment is installed.

Third, value the people. Each employee brings a set of skills that can be leveraged to the good of the project. In this project three diverse sets of background contributed to the success of the Reconfiguration Project at Sandia National Laboratories and to improvements that occurred after a War Reserve production capability was established for neutron tubes and generators. These were: production experience at the PP, research experience at SNL/NM, and production experience in the private sector.

Fourth, expect to grow the culture. An organization must define the culture that will foster success of the project or program and then take definitive steps to evolve from the existing state to what is desired. This project demonstrated that defining the end state and implementing it, without awareness of the present state and the steps required to change the existing state to the desired state, did not work.

Results

The Reconfiguration Project was completed on schedule, and War Reserve neutron generators were in bonded stores in August 1999, two months ahead of schedule. Critical milestones were individually completed on schedule. Major items included facility design and construction, equipment acquisition and installation, RA, process qualification, trained workforce, and War Reserve product certification. Since October 1999, additional improvements have been realized.

Product

When War Reserve neutron generators were placed in bonded stores in August 1999, the objective of the Reconfiguration Project was achieved. The transfer of the production of War Reserve neutron generators from the PP to SNL/NM had been demonstrated. However, the capacity was approximately 700 units a year. The completion of the Rapid Reactivation Project in January 2002 increased the capacity of the facilities to about 1500 units a year, but there were insufficient floor operators to deliver this higher capacity. By 2004, increased production efficiency raised the capacity to about 1000 units a year without adding additional floor operators to the number in existence in 2000. Additionally, the capability to prototype neutron tubes was upgraded, and the capability to prototype neutron generators was added.

Cost Savings

Collocation of design and production of neutron generators at SNL/NM has produced additional benefits. The principles and techniques described in this report were used when tritium target loading was successfully moved from Los Alamos National Laboratory to SNL/NM in 2005. Common Corporate goals, metrics, and accountability helped to increase yields with commensurate lower production costs. Increased agility and flexibility through Lean Six Sigma have resulted.

In 2005 dollars, it is estimated that the Reconfiguration Project has saved the NWC about $38 million a year since the PP closed at the end of October 1995. The payback period is about 4.6 years. Transferring tritium target loading from Los Alamos to SNL/NM saves an additional $5.5 million a year beginning in 2006. Improved production efficiencies realize an additional $3.6 million a year in savings. In all, the Reconfiguration Project, movement of tritium target loading, and improved production efficiency saves the NWC $47.3 million a year.

Processes

The Reconfiguration Project has been a springboard for process changes. An approach to shorten design of new construction has been demonstrated. Up to four months can be removed from the design time by having dynamic reviews of the design package. This approach requires careful coordination within the project and with DOE to realize the benefits. Today, the RA process across SNL/NM is typically staged. The level of breakdown is commensurate with the needs of individual projects but is typically laboratory by laboratory or room by room. Implementation of Lean Six Sigma has produced a production environment at SNL/NM that is different than all other Production Agencies throughout the NWC. For example at SNL/NM, most quality assessment of War Reserve product occurs by operators rather than a separate quality assessment group. The efforts of the Production Center at SNL/NM have been recognized in 2006 through the receipt of the Bronze Shingo Award, the New Mexico Roadrunner Quality Award and with the Production Center becoming ISO 9000 registered.

Note to Reader: The information for this report was taken from formal and informal documents available to the author, complimented by the memory of those who were involved. Since some dates came from memory, it is recognized there could be a few months error in some dates. This is not deemed to be critical, because the primary purpose of the report is to capture the process of moving production to a national laboratory. The intent is to capture the challenges of the project and the "can-do" attitude of those involved, to which I attribute its success.

PREFACE

Introduction

This report focuses on the transfer of production of War Reserve (WR) neutron tubes (NTs) and neutron generators (NGs) from the Pinellas Plant (PP) to Sandia National Laboratories, New Mexico (SNL/NM). The author was asked to compile this report because he was part of the Reconfiguration Project from its beginning and was part of the Management Team for production of NGs at SNL/NM through December 2004. Some of the dates in this report are approximate, because they were reconstructed from memory. A slight inaccuracy in a date is not considered critical, because the report focuses on the process, which is what would provide valuable insight if further compression of the Nuclear Weapons Complex (NWC) should occur in the future.

The author had private industry experience and had a wide range of responsibilities during the Reconfiguration Project that provided a broad view of all of the activities. Specifically, the author was: a member of the Executive Planning Group, a member of the Activity Transfer Team, and the point of contact for facility construction. He also was responsible for equipment transfer from the PP, equipment storage at SNL/NM prior to installation, equipment installation, acquisition of new equipment, design and fabrication of equipment not commercially available, the RA process, development of a Production Trades program, coordination of the National Environment Policy Act (NEPA) process to assure compliance to requirements, and WR qualification of evaporation, exhaust and brazing processes for NT fabrication. The author was also the project lead for the effort that established a NT prototyping capability in the East Annex of Building 870.

Historical Perspective

In the late 1980s it was apparent that the budget for the NWC needed to shrink, or as a minimum would not grow at the rate of inflation. The total number of weapons in the stockpile was decreasing and new weapons design was on hold. The Department of Energy (DOE) led a committee to evaluate the budget issue. The DOE-led committee came to the conclusion that the only way to respond to the shrinking budget was to close facilities. Harry Saxton was the Sandia National Laboratories (SNL) representative during this planning activity. In early 1991, a decision was made to formally explore the possible closure of the PP in Florida, the Mound Plant in Ohio, and the Rocky Flats Plant in Colorado. When the Reconfiguration Project was approved for implementation, Harry Saxton was the Program manager to implement the transfer of production of NGs from the PP to SNL/NM.

The preliminary capacity for NG fabrication was forecast to be 600 units a year; 500 units for delivery to the Stockpile and 100 units for development. Due to the low number of units, development and production were to use the same floor space and the same equipment. Facility and equipment at SNL/NM were scoped to meet the capacity of 600 NGs a year. In late 1995, before construction of Building 870 was completed, it became clear that the capacity of 600 units a year was low, when both the active and inactive stockpile was considered. Forecast capacity levels had increased to approximately 1500 units a year with 200 units supporting development. A Rapid Reactivation project was initiated in late 1998, completed in early 2002, to increase production capacity at SNL/NM from 600 units a year to the higher demand of 1500 units a year.

In parallel with the early stages of the Reconfiguration Project, a capability to prototype NTs was established in the East Annex of Building 870. The prototyping activity would eventually support WR NT fabrication, since development and production would use the same floor space and the same equipment. A prototyping activity for ferroelectric NGs was initiated in Building 878. As production was established at SNL/NM the prototyping of ferroelectric NGs was combined with WR production in Building 870.

Timeline

In Appendix A, a detailed timeline is presented of activities from the late 1980s through 2004. In this section a more abbreviated summary is presented. In the late 1980s a report was prepared that evaluated the closure of production plants and potential sites within the NWC that WR production could be transferred to. In the spring of 1991, the report was made available to the larger NWC community. Early in the summer of 1991, each potential receiving site walked the production floor space for products that might move to them and prepared a preliminary report regarding the transfer process of each production activity.

In December of 1991, Admiral Watkins, Secretary of the DOE, identified the plants slated for closure and the preferred sites to which production activities would be transferred. Relative to WR NG fabrication, the PP was slated to close October 1995. The transfer of NG production from the PP to SNL/NM was to be completed, processes were to be qualified, and product was to be available in bonded stores for shipment by October of 2000.

Late in 1993 delivery schedules indicated that the PP could be closed one year earlier (October 1994) with significant cost reductions to the Reconfiguration Project. The completion date for the Reconfiguration Project was moved up to October 1999, even though product was not required until October 2000. The length of time from PP closure to qualification at SNL/NM was kept constant at 5 years. This decision complicated the transfer process because the PP would close before facility modifications and new equipment installations could be completed at Sandia. Tritium target loading verification measurements could not be made at SNL/NM to support loading verification at LANL. Analyses other than target loading could not be cross checked between SNL/NM and PP before the PP closed. Controlatrons would have to perform for an additional year before replacement units were available. Transfer of cermet technology to the private sector would have to occur with one year less time. Equipment transferred from the PP would have to be stored at SNL/NM up to 18 months before installation could be performed at SNL/NM.

Conceptual Design Reports (CDRs) were prepared from January 1992 through October 1992 for each production activity scheduled to be moved. Sandia National Laboratories, New Mexico prepared two CDRs and assisted in the preparation of a third; the first CDR was a stand alone building that could be managed by a contractor like Kansas City, the second CDR addressed the movement of NG production to Kansas City, and the third CDR addressed movement of NG production to SNL/NM, but with a stipulation that existing buildings would be utilized to the maximum extent possible. The third option was eventually selected for implementation. The first option was too expensive. The second and third options were comparable in cost, but the third option was selected because it located production and design activities at one site with a concomitant reduction in risk.

With the election and a new President of the United States in 1993, and from a different political party, the decision to implement the Reconfiguration Project was delayed until the new administration could evaluate and validate the Reconfiguration Project. Hence, authorization was received to continue the CDR process to better define and refine the relocation process, specifically the cost estimates, the relocation plans, and design of a modified/new facility at SNL/NM. For the new construction, an Engineering Evaluation Study was completed during the spring of 1993 to assure the proposed project was cost effective over the expected life of the new building. Adjustments were made to respond to the recommendations of the Engineering Evaluation Study. The new Administration received a report early in the summer of 1993 that recommended that the Reconfiguration Project should be implemented. Formal authorization to initiate the Reconfiguration Project was received by SNL/NM on September 3, 1993.

A contract was immediately released to design and construct Building 870. Design was completed in June 1994. Construction of a new wing to Building 870, and modifications to the existing wings of Building 870, began in September 1994. Construction was to be completed by January 1996, 16 months later. Modification of the East Annex of Building 870 was completed as part of a NT Prototyping Project. Construction of Building 870 was completed in December 1995 within budget. As part of this construction, the East Annex was integrated with the new construction to support NT fabrication.

War Reserve production at the PP ended October 1994. During 1994-1995, equipment was disconnected at the PP, was shipped to SNL/NM, and was stored from 6-18 months prior to installation. A staged RA was completed during 1996, with different parts of Building 870 being authorized for use at different times during the year. Areas supporting NT fabrication and analytical support came on line in June 1996 with NG and tester areas authorized to operate by December 1996. Qualification of processes began for NTs in mid 1996 and for NGs early in 1997. The NT line was WR qualified in November 1997. The NG line was WR qualified late in 1998. A critical NG reliability test was completed in July 1999, and WR NGs were in bonded storage by August 1999. This was sixty days before the Reconfiguration Project completion date of October 1999.

In 1992 a decision was made to move NT prototyping from Building 891 to the East Annex of Building 870. This would move tritium operations from a highly-populated building in the center of Tech Area I to a less populated area; this area is no longer a less populated area. Moving the Neutron Tube Laboratory was viewed as something that should be done regardless of any final Reconfiguration decision, because equipment in the Neutron Tube Laboratory needed to be updated, and the move would free up space in Building 891 to accommodate other critical requests. Capital equipment funds were made available so on-going prototyping activities could continue in Building 891 during facility modifications to the East Annex of Building 870 and the installation and technical qualification of newly purchased equipment. Neutron tube prototyping began in the East Annex of Building 870 early in 1995, while the balance of Building 870 was still under construction.

Since putting the first WR NGs into bonded storage August 1999, improvements in production processes have continued to the present time. A production culture was established within a National Laboratory. Process yields of many processes began at 50%, and are now greater than 90%. Lean/Six Sigma manufacturing techniques have been implemented to shorten span times and to eliminate waste in the fabrication processes.

PRE-PINELLAS PLANT CLOSURE

Initial Walk through

A cross-cutting team from SNL/NM was assembled to walk the production floor space in the PP. This team was comprised of: program management, NT design, NG design, analytical techniques, process experts, subject matter experts, and facilities. The purpose of the walk through was to assess if production of WR NGs could be transferred from the PP to SNL/NM? Did SNL/NM have existing capabilities or could SNL/NM quickly develop needed capabilities? Was SNL/NM willing to accept a production mission assignment for WR NTs and NGs?

Facility footprints of the PP were obtained and locations were identified that contributed to the WR fabrication of NTs and NGs, analytical support, ceramic processing, and piece part machine shop fabrication. Approximately 50% of the 750,000 square feet of floor space in the PP was used for NG production or for the support of NG production. Small groups were identified to walk each area. A facility person was included in most groups. Leads for each group were identified. The floor space for each activity was divided by capability, and each room within a capability was examined. In each room, all equipment was noted as being required, not required, or decision to be made after further consideration.

Status meetings were held each evening to address questions. Equipment lists were refined as to what was required for NG production at SNL/NM. It was decided, for example, that machine shops existed at SNL/NM and in metropolitan Albuquerque; hence, no piece-part machining capability would be transferred from the PP to support NG production at SNL/NM. Procurement of machined piece parts would be outsourced from the production group to the commercial sector or to the SNL/NM machine shops. Similarly, it was decided that ceramic processing would not be transferred. Ceramic parts would be procured from the private sector. This report will not cover the recommendation for every capability, but these examples are provided to outline the process.

Target Loading at LANL

As plans proceeded at DOE Headquarters for the Reconfiguration Project, the intersection of NEPA regulatory requirements and the Reconfiguration Project were addressed. If NG production was relocated to SNL/NM, a nuclear facility question had to be addressed within the time available for the production assignment transfer. In 1991 the tritium inventory for a Category III nuclear facility was 1000 curies. Movement of target loading to SNL/NM would introduce tritium at SNL/NM to a level greater than this amount. National Environment Program Act regulations would require an Environmental Impact Statement (EIS) to be prepared and a nuclear facility to be constructed. The time to complete an EIS and to construct a nuclear facility was longer than what was available within the Reconfiguration Project. In comparison, an Environmental Assessment (EA) could be completed within the timeframe that was available.

For these reasons, NT design and NT prototyping at SNL/NM were tasked by DOE in the fall of 1991 to assess the viability of performing target loading at a site different than the one that fabricated the NT. To explore this option, a single experiment was completed. Targets, except for loading, were prepared at the PP using standard WR techniques. The targets were divided into two groups. The first group of targets was loaded to the WR specifications at the PP. The second group of targets was sent to Sandia National Laboratories, California (SNL/CA) who at the time had a tritium processing facility. The recipe was provided to the SNL/CA site, and the second group of targets was loaded there. Targets from each group were analyzed. Results were similar. Two NTs were fabricated from each group (four tubes in total) at SNL/NM in the Tube Prototyping Laboratory. The tubes were tested for neutron output. The four tubes all met output requirements. One could not identify the loading location from the results. Hence, it was concluded that off-site loading by an inexperienced site was possible. Hence, NT fabrication could be transferred to SNL/NM and target loading could be transferred to a different site.

Based on this experiment, the decision was made to move tritium target loading to an existing tritium processing site that already had nuclear facilities, if production of NGs was moved to SNL/NM. Both Los Alamos National Laboratory and the Savannah River Site met the requirements. Due to the closer proximity of Los Alamos to SNL/NM, Los Alamos was selected as the preferred site for tritium target loading. Technical personnel who had been involved with the loading process at the PP assisted in the establishment of tritium target loading at Los Alamos.

Management Structure

A project management structure was established at SNL/NM to implement the Reconfiguration Project. Harry Saxton was the Program Manager. He coordinated the project with SNL/NM Management and worked with the team to resolve issues. An executive committee was formed to provide an integration function to the various activities assigned to subject matter experts. This team consisted of:

Project Manager: John Gronager
Activity Transfer Plan: Tom Cutchen
Budget/Financial: Bill Cleveland
Facilities: Tom Faturas, Carol Meincke (a transition occurred during the project)
Manufacturing: Larry Pope

The executive committee met on a regular basis to assess status, to provide priorities, and to work issues as they surfaced. Subject matter experts were assigned to major areas of responsibility, and members of the executive committee coordinated efforts within their areas of responsibility.

Capabilities/Requirements

The walk through of the PP identified capabilities that were to be transferred. Within each capability, requirements were listed to assure the ability would exist to fabricate WR NGs at SNL/NM. In addition, a detailed list of required equipment was prepared. Collocation and adjacencies of different process functions were identified. Tentative flow diagrams were prepared. Critical skills were identified. Personnel should be transferred from the PP to SNL/NM to address the critical skills which would reduce the risk of transferring production of NGs to SNL/NM. It was recognized that the technology existed at SNL/NM, but that experience in WR production rigor was foreign to SNL/NM. Perceptions existed at SNL/NM regarding production, because of the extensive interactions that had occurred among the PP, the design groups and other subject matter experts at SNL/NM.

From the list of capabilities, a general estimate was developed as to floor space, electrical power, and other utility requirements to support a WR NG production mission assignment. These results were communicated to DOE with a conclusion statement that SNL/NM was capable of manufacturing WR NGs. Also, SNL/NM was willing to accept the mission assignment for production of NGs. Though the schedule was very aggressive, confidence existed at SNL/NM that the schedule could be met, if adequate support was made available from the PP, SNL/NM and DOE.

The greatest concern was that the MC4277 NT was in the final stages of development. Production of this product had not occurred at the PP. Limited difficulties had been experienced in prototyping at SNL/NM and pre-production development at the PP, so design and development groups were optimistic about the new NT. Hence, a production mission assignment was being transferred from a production facility that had completed prototyping of the NT (but not the NG) to a National Laboratory that had the technology and a NT prototyping capability (but not a mature NG prototyping capability) and no experience in WR production.

Conceptual Design Reports

Three different CDRs were prepared for the relocation of NG production from the PP. The first and third CDRs were prepared by SNL/NM, and these reports examined the transfer of NG production to SNL/NM. The second CDR examined a move to the Kansas City Plant; Kansas City Plant personnel prepared this report with assistance from SNL/NM.

The first CDR was prepared between January and May 1992 under a contract managed by DOE Headquarters. The assumption for this effort was that the production activity at SNL/NM would be a stand-alone capability such that SNL/NM could contract with a Production Agency for operation of the activity, similar to the Kansas City operation of microcircuit production at SNL/NM. A stand-alone building implied that none of the SNL/NM infrastructure would be made available. Medical, shipping and receiving, security force, and technical library, for example, would be contained in the NG production building. The cost of such a building was prohibitive, and it would have been preferred to keep the PP open at a significantly reduced level. This option was dead before it was finished, because of its cost.

The second CDR, prepared by Kansas City with support from SNL/NM between March and June 1992, explored moving NG production to Kansas City. This CDR was initiated before the first CDR was finished. This option was cost-wise viable, but did not address the risks associated with moving a production activity to a plant where the technology was foreign to existing manufacturing responsibilities. When NG production was moved from Milwaukee to the PP, almost a year transpired before good product was yielded at the PP. The aggressive schedule could not accommodate a similar length of time to establish a WR operation for NGs. Risk was the principal reason the move to Kansas City was not selected.

The third CDR prepared between July and October 1992 explored moving NG production to SNL/NM, but there was no constraint that production had to be a stand-alone operation. In fact, instructions were given that existing buildings were to be used to the maximum. Further, the infrastructure in place at SNL/NM was to be used without duplication. The request for the third option came to SNL/NM in July of 1992, and was finished by October of the same year. The budget for this option was submitted at the end of August 1992. The cost of this option was about $75 million, which was comparable to the move to Kansas City. Since SNL/NM successfully prototyped NTs and the design organizations were in place at SNL/NM, this option was deemed to be lower risk than a move to Kansas City. Movement of production to SNL/NM as described in the third CDR became the preferred option.

From October 1992 through August 1993, refinements were made to the third CDR. Design time for Building 870 construction was reduced. This proposal modified one of the existing wings in Building 870 (the West Wing), demolished the balance of the building except for the East Annex, and replaced the demolished portion of Building 870 with a basement and two stories above the basement. The East Annex was modified as part of the NT Prototyping Project. The newly constructed portion of Building 870 was connected to the existing wings making Building 870 an intact structure.

Activity Transfer Plan

An Activity Transfer Plan was prepared between the spring 1993 and October 1994 to describe all aspects of moving production from the PP to SNL/NM. Assumptions and paradigms were explained. The Activity Plan was finalized in 1994 prior to closure of the PP. Only two parts of the plan will be briefly discussed here; and that is to be illustrative of the detail that was considered relative to each activity. This report is limited to a discussion of equipment transfer and/or purchase and critical skills.

Equipment Transfer Paradigm

In the spring of 1994 DOE determined that the PP could be closed a year earlier at the end of September 1994 without compromising the ship schedule. This would save one year of operational expenses at the PP (about $100 million). The length of the Reconfiguration Project was kept constant, so the completion of the Reconfiguration Project was pulled up from October 2000 to October 1999, even though the ship schedule would have accommodated the later date. This decision meant that equipment would be disconnected at the PP and shipped to SNL/NM before construction of Building 870 was completed; hence, the equipment would have to be stored at SNL/NM for 6 to 18 months prior to installation. Negotiations were completed for the environmental test organization to move out of Building 882 earlier than planned to provide a storage location for equipment shipped from the PP plant and for a staging area for new equipment procured as part of the NT Prototyping Project.

Based on walking the production floor at the PP, an equipment list was prepared as to items required to complete NG production at SNL/NM. The equipment list was refined and finalized. The expected life of each equipment item was estimated. Experience of subject matter experts was used in combination with maintenance and repair records at the PP. The PP would close at the end of FY04 (September 1994). Items to be transferred would be disconnected, shipped to Albuquerque, stored in Building 882 until construction of Building 870 was completed, and then installed in Building 870. Following installation, the equipment would be operated to demonstrate technical capability before process qualification occurred. It would be disruptive to replace equipment in the middle of the qualification process. Further, replacing equipment during the initial years of WR production should be avoided. Qualification would begin in 1997. WR product should be in bonded stores by October 1999. To avoid equipment change out during the first four years of production, only equipment that had an expected life to or beyond 2003 was transferred. Items not transferred were to be purchased new. About $3.5M was identified for purchase of equipment at SNL/NM. Another $30M in equipment and testers were identified for transfer to SNL/NM from the PP.

Many of the testers that were transferred, the Vanguard test data and the record of assembly management system, for example, were obsolete. Because of cost, time and impact to production schedules, it was not possible to refurbish or update the testers during the transfer to SNL/NM. Though stored electronic data could be retrieved, it was cumbersome and difficult to retrieve the data. This led to an expensive effort to reestablish this obsolete capability. This is a legacy that SNL/NM is still struggling to correct as this document is written.

In June 1993, the Secretary of Energy announced that some equipment would be left in the PP to assist in the transition of the vacated PP to private sector economic endeavors. Approximately $6M of equipment on the transfer list was identified as crucial to the economic development activities at the PP. Most of this equipment was analytical in nature. A special allocation was approved by Congress that allowed new equipment to be purchased to replace the equipment left at the PP. Hence, equipment and testers with an approximate value of $24 million were transferred and $9.5M of new equipment was purchased.

Disconnection and Reconnection Process

The PP had identified equipment that required periodic calibration to assure WR requirements were met. After the last WR product crossed these equipment items, these items were calibrated before disconnection occurred to assure the quality of shipped WR product had been maintained. Disconnection of equipment at the PP started in October 1994 and was completed by the end of September 1995.

A checklist was prepared for each equipment item that assured regulatory requirements were met, that performance data was captured, and that the item met Department of Transportation requirements for shipping. Tritium contamination was the main concern. When tritium contamination was found, decontamination occurred at the PP before shipment.

A subject matter expert from the SNL/NM site or from personnel at the PP who would transfer to SNL/NM was identified for each item of equipment. This individual (in combination with maintenance and repair, facility, and process engineers from the PP) oversaw the disconnection process. The same subject matter expert was responsible for the installation at SNL/NM. The equipment was stored in Building 882 at SNL/NM for up to 18 months after shipping and before installation. Only one piece of equipment had to be replaced during installation, which validated the equipment transfer paradigm. The assigned subject matter expert was also responsible to assure that the equipment functioned to the same capability at SNL/NM as it had at the PP before disconnection. Most often, this individual was the process engineer responsible for WR qualification of the process that used the equipment.

Equipment Procurement

A plan for equipment procurement was initiated in July 1994. Jim Gebhart was transferred from the PP to finalize the procurement plan and to coordinate procurement. A subject matter expert was assigned to each piece of equipment on the procurement list.   Some items had a delivery schedule of 4-9 months. The challenge was to place a purchase order on a schedule that did not have the equipment delivered to SNL/NM before the construction of Building 870 was completed, yet with sufficient lead that the equipment was in place and operational to support the RA process and the WR qualification of product. A staggered schedule existed for the assessment and qualification processes to support product flow through the production line.

Critical Skills

In the fall of 1993 a list of critical skills was developed for production of NTs and NGs at the PP. These same skills would be required to support WR production of NGs at SNL/NM. The list contained management, technical staff, and technologists. Floor operators would not be transferred from the PP to SNL/NM. It was not clear what floor operators would do when equipment was in storage. Further, at the PP floor operators were not union, whereas the operators at SNL/NM would be represented by the Metal Trades Council (MTC). It was felt that technicians, technical staff and management could train floor operators at SNL/NM during startup activities.

For each critical skill, a job description was written early in 1993. The job descriptions and number of positions were posted at the PP to allow individuals to self identify. Interview teams from SNL/NM interviewed all who expressed interest in the March/April timeframe and selected those who best met the job descriptions. Managers, technical staff and technologists were offered jobs to transfer to SNL/NM and become part of the production operation. A total of 83 individuals were transferred to SNL/NM as part of NG production. Other PP employees transferred to SNL outside of the Reconfiguration Project.

The first PP employees transferred to SNL/NM in July 1994 to meet specific needs at SNL/NM. A few employees were transferred over the next few months. The majority of PP employees transferred to SNL/NM in September/October 1995. The last PP employees transferred to SNL/NM in December 1995.

Since many of the PP employees would move to SNL/NM before construction of the West Wing of Building 870 could be completed (scheduled for August 1995), accommodations for personnel transferring from the PP became a critical issue. Two separate activities were initiated to address this office space shortfall. In mid July 1994, four mobile trailers (MO160, MO161, MO162, and

MO163) were identified for transfer to near Building 870. The first occupants moved into these trailers October 24, 1994, three months after the decision was made. Second, a General Plant Project (GPP) construction project (Building 879) was completed. Design occurred from August 1994 to October 1994. Construction began in December 1994 and was completed November 1995. The trailers, the West Wing of Building 870, and Building 879 addressed the short-term office space needs.

START-UP ACTIVITIES AT SANDIA NATIONAL LABORATORIES

Neutron Tube Prototyping in East Annex

In July 1992, a decision was made to move the NT prototyping activity from Building 891 to the East Annex of Building 870. Several factors contributed to the decision, and these included: no tritium operations could be completed in Building 891 until the ventilation system was repaired, equipment in Building 891 was old and out-dated and could not support WR fabrication, insufficient space in Building 891 to add equipment to support the transition from development to production and to prototype switch tubes, movement of tritium operations from a high-population building in the center of Tech Area I, and the equipment in the Neutron Tube Prototyping Laboratory needed to be upgraded and replaced while maintaining a concurrent capability to prototype the MC4277. The move of prototyping of NTs to the East Annex of building 870 was synergistic with moving production to SNL/NM, since both development and production were to use the same equipment. The decision to move the Neutron Tube Prototyping Laboratory to the East Annex of Building 870 was a sound one, even if production of NGs was not moved to SNL/NM. In parallel, a prototyping activity for NGs was established in Building 878, so SNL/NM would have both a NT and a NG prototyping capability.

Though this project was independent of the Reconfiguration Project, one of the requirements was that a transition could be made to fabricate WR NTs within the East Annex of Building 870. Equipment had to be flexible enough to support development activities and also had to able to meet the requirements for WR fabrication of NTs. Neutron tube prototyping in the East Annex of Building 870 would support the transition from development to production, regardless of the eventual decision for the Reconfiguration Project. It was further recognized that establishment of prototyping in the East Annex of Building 870 would shorten the schedule for putting the first production unit of NGs into bonded stores, if the Reconfiguration Project was implemented. Further, this capability would support bringing tritium target loading on line at LANL by fabricating NTs whose targets were loaded at LANL.

Preliminary planning for facility modification to the East Annex of Building 870 began August 1992 with formal design occurring in 1993. Construction began in March 1994 and was completed December of 1994. A special allocation of $5.0 million was received from DOE to procure the new equipment in support of neutron/switch tube prototyping, NG prototyping, and timer/driver prototyping. To accelerate the project, all new equipment for neutron/switch tube prototyping was staged in Building 882 during the construction of the East Annex and prior to installation in the East Annex of Building 870. Equipment was purchased during 1993 and early 1994, depending on the length of time for technical verification to procurement specifications. The capability to prototype NTs was demonstrated in the East Annex of Building 870 during the third quarter of calendar year 1995. Prototyping continued while the construction of Building 870 was finished. War Reserve qualification of NTs began in mid 1996.

Compliance to Regulatory Requirements

In late 1992 two teams were established at SNL/NM to address regulatory requirements. The composition of the teams was established to cover the broad basis of documentation, air, water, NEPA, and safety. The first team addressed the movement of WR production of NTs and NGs from the PP to SNL/NM. The second team addressed the move of NT prototyping from Building 891 to the East Annex of Building 870. The two teams coordinated their efforts for NT fabrication to assure a common approach for both prototyping and WR production of NTs.

The NEPA requirements for the Reconfiguration Project were met through an EA Report that was prepared under the direction of DOE, Headquarters. The team established to support the Reconfiguration Project was primarily responsible for providing information to DOE for the EA and to assure that activities within SNL/NM were properly managed to assure compliance. Fire Safety was covered as part of the building design and construction. A discussion of the RA process is found later in this report.

Initially, it was believed that an Operational Readiness Report (ORR) commensurate with nuclear facilities would be required at SNL/NM. Preparation of a detailed Safety Assessment (SA) was part of the ORR process. While it was being evaluated to determine if an ORR would be required and to assure the schedule could be met, a SA was prepared for the Prototyping Project and a second SA was started for the construction of Building 870. Clarity received part way through the project indicated that SA reports were not required for non-nuclear, low hazard facilities. Neither was an ORR needed. The rigor for non-nuclear, low hazard facilities required a RA to be prepared.

For the NT prototyping activity, in the spring of 1993 an external consultant completed several accident scenarios to assure safety for employees and the public had been addressed. Not knowing if production of NGs would be moved from the PP to SNL/NM, the analyses were broad enough through different options to address the safety of employees and the public for production activities. The information from the accident scenarios contributed to the standard NEPA Checklist that was submitted to DOE for a NEPA determination for the NT prototyping project. The accident scenario reports were part of the basis for the hazard analysis completed as part of the RA process. An EA was required to move production from the PP to SNL/NM, and the EA was coordinated by DOE as part of the Reconfiguration Project. The Prototyping Project received a Categorical Exclusion because the NT prototyping activity was being moved from one building to another building within Tech Area I, with no additional hazards and no additional environmental issues. Other than the NEPA determination, the prototyping and ES&H teams addressed all compliance issues associated with facility modifications to the East Annex of Building 870 and the movement of prototyping of NTs to that space.

Design and Value Engineering of Building 870

Standard protocol was used for the design of Building 870; therefore, the design process will not be explained with two exceptions. First, a few years earlier ethylene glycol had been spilled on the road to the north of Building 870 at SNL/NM. To avoid penetrating a possible environmental restoration site with unknown time and costs to reclaim the site, the basement of Building 870 was designed to not extend to the northern perimeter of the first floor of the building. This permitted the aggressive schedule of the Reconfiguration Project to be met without the uncertainty of cleanup of a restoration site. Second, due to the political environment, when SNL/NM was selected as the preferred site to receive NG production, a boundary condition was given to SNL/NM that Building 870 would be used and also that the footprint of building 870 would be maintained.

Building 870 was a compilation of at least seventeen different construction projects spread over about twenty-five years, and the perimeter of the building had numerous jogs. The interior of the building was not conducive to product flow. Two of the wings (the East Annex and the West Annex) were of recent construction. The external structure for these two wings was kept, with internal modifications to meet seismic requirements and production needs. The balance of Building 870 was demolished and replaced with a basement to hold building utilities and a second floor to obtain the square footage required for production activities. However, the footprint of the building coincided with the initial footprint.

During the spring of 1994, a Value Engineering Study was completed to assure that the expenditure of taxpayer funds was realizing an effective life cycle value. This study recommended that the perimeter of the building should be straightened out. Additionally, for a minimal cost, 20,000 square feet of additional office space was added on the second floor of building 870. These recommendations were incorporated into the Title II activities for Building 870 design, resulting in Building 870 having its present footprint and a full second floor above the new portion of the building.

Construction of Building 870

Authorization was received September 3, 1993, for SNL/NM to implement the Reconfiguration Project. A contract was placed with an Architectural Engineering firm for the design of Building 870. The CDR was the foundation for this activity. Requirements were refined. Adjacencies were examined again.

The design and potential impacts to the design were on the critical path. Yet, quality of construction and building capability could not be compromised. The standard cycle of completing Title I (approximately 60%), stoppage of design during evaluation and comments to the Title I package, completing Title II (100%), evaluation and comments to the Title II package, and response to comments prior to a competitively bid process to select a construction contractor required more time than was available. The time for design of building 870 had been shortened to 9.5 months.

During the fall of 1993 negotiations were completed with the DOE facility team, the internal to SNL/NM evaluation groups, and the user community to complete the evaluation and comments portion of the design dynamically. This meant that as Title I approached, documents were prepared to give the status at the selected date. The documents were distributed to all concerned parties with a pre-planned 1 week evaluation time before the formal report out of Title I status. Each person either communicated their preliminary comments at the report out meeting, or before. During the evaluation, design continued into Title II. At the Title I report out meeting all issues were discussed. No major roadblocks were identified. At the end of the meeting authorization was received for Title II activities to continue. An additional week was provided for evaluators to make comments on issues that surfaced during the Title I report out. All comments were integrated into a package and were incorporated into the Title II activities. This approach removed about 3 months from the typical design schedule.

The same process was used for the Title II report out, which occurred in June of 1994. It was likely that Congress would not pass the budget authorization, leading to a Continuing Resolution in October of 1994. A Continuing Resolution would have precluded the initiation of any new activity until the Budget Resolution was resolved, which would have had a catastrophic impact on the schedule of Building 870 construction. Hence, as the Title II package was prepared for the report out meeting, the bid package was prepared in parallel to the evaluation and comment period. Based on the Title II report out meeting, adjustments were made to the bid package, and it was placed on the street. After final comments were received, an addendum to the bid package was sent to the interested construction companies. Bids were received and a contractor was selected with the requirement that the construction project begin before the end of September 1994. The construction of Building 870 would be a continuing project, rather than a new project; hence, a Continuing Resolution could not delay the project. A Continuing Resolution occurred, which would have delayed the project at least 3 months, which would have caused irreparable damage to the schedule. This approach removed another 4 months from the typical design schedule and avoided at least an additional 3 month delay.

By February of 1995, it was clear that the construction project was almost 3 months behind schedule. A root cause analysis revealed that two major issues contributed to the project being behind schedule. First, the request for information by the contractor and subcontractors from SNL/NM took an inordinate amount of time, leading to inefficiencies and lost time in the construction. Second, the interrelationship between the subcontractors was inadequate, resulting in negative impacts to the overall project schedule.

In a strategy meeting, a potential solution emerged. An external facility construction subject matter expert would be found. This individual, or firm, had to be well versed with the construction process, with prior experience relative to subcontractor interrelationships. The construction contractor, with input from SNL/NM project management, coordinated the interactions among the subcontractors to remove time from the critical path to bring the building construction back on schedule. The idea was socialized with the contractor and the subcontractors. The idea was accepted and was implemented in March 1995. A massive project plan was put in place that included the details of all activities for each subcontractor. Predecessor and following activities were identified. The project plan was utilized to negotiate subcontractor priorities for the overall schedule. Electrical and mechanical workers were placed on a 50 hour work week. All critical path items were put onto a 60 hour work week. A swing shift was added in June 1995. The implementation of this approach and the lengthened work week for selected areas of expertise exceeded expectations.

Construction of the West Wing of Building 870 was completed July 1995 and occupancy was primarily by employees transferred from the PP. The clean rooms and analytical services laboratory space on the first floor of the North Wing was received December 12, 2005, 60 days ahead of schedule, and installation of equipment in this space began before Winter Break. The balance of the North Wing of Building 870 was received on January 13, 1996, 30 days ahead of schedule. Equipment installation in this space began on January 15, 1996.

Equipment Installation

The PP completed its WR fabrication of NGs at the end of September 1994. As WR processing ended on a piece of equipment, calibration and collection of performance data occurred to the degree specified by the assigned subject matter expert. Upon completion of these two activities, the equipment was disconnected and shipped to SNL/NM. The equipment was inventoried upon arrival at SNL/NM, but was neither unpacked nor removed from shipping pallets or shipping containers. The equipment was stored in Building 882 between its arrival at SNL/NM and installation in Building 870. The length of storage time varied from 6 months to 18 months. All of the equipment had been shipped from the PP by October 1995.

A strategy for installation was developed item by item to support the programmatic schedule of establishing WR fabrication of NGs at SNL/NM. Neutron tube fabrication needed to be qualified first; hence, NT processes and the analytical support required for NT processes had the highest priority. Most of the processes to fabrication NTs would occur in the East Annex of Building 870, and the capability to support these processes was established as part of the prototyping activity that was completed in 1995. The balance of the processes utilized during the fabrication of NTs (evaporation and exhaust, for example) and analytical support had new equipment either fabricated internally at SNL/NM or procured from the private sector. This equipment was installed in the newly constructed North Wing of Building 870.

Installation of equipment was coordinated with the RA process, discussed in the next section. Since the equipment that was transferred had been operating at the PP with existing safety documentation, the decision was made to accept the ES&H documentation from the PP without further review from SNL/NM Safety Engineers. After installation of each transferred piece of equipment, utilities were connected to the specifications developed at the PP prior to disconnection. Subsequently, each piece of equipment was operated to obtain a duplicate set of performance data to what was obtained prior to shipment. This validated the technical performance of the equipment. Process characterization began and process capability was established. The data ultimately was captured in Process Qualification Reports. When all of the NT processes were qualified, the NT was able to produce WR NTs. Only 1 piece of equipment transferred from the PP did not produce duplicate performance data, and that item was replaced through procurement.

In parallel with installation of NT equipment, analytical equipment was installed. Most of this equipment was new, so after installation the supplier came to complete acceptance testing and to assure the equipment functioned to the procurement specifications. This equipment also underwent a qualification process to assure analytical data supported production operations.

The same process was used for equipment on the NG production line and for testers that accepted product. All equipment was installed within Building 870 by the end of 1996.

Readiness Assessment

The RA process is intended to assure that the facility and equipment can be operated safely and precedes demonstration of WR quality. The typical approach for RA at SNL/NM was to complete new construction, install the equipment, complete the utility connections, and prepare all of the paperwork before performing the assessment. The assessment would take a week or more to evaluate the safety of the building and equipment and to verify the qualification of operators. Findings were corrected and assessed a second time. The standard approach did not meet the time requirements for the aggressive schedule of the Reconfiguration Project.

At the beginning of the Reconfiguration Project, it was not clear who was accountable to complete the RA process. Hence, dialogue occurred amongst the users (represented by the author), the SNL/NM Safety Organization, and DOE to agree on a path forward. Midway through the project (approximately summer of 1995), it became clear that the Line Organization owned the RA process with oversight provided by the Safety Organization and DOE. The RA documentation was provided to DOE as part of the facility construction completion, and DOE examined the documentation to assure adequate controls were in place prior to their issuing final approval to use the building for its intended purpose.

To accommodate the aggressive schedule of the Reconfiguration Project, permission was received to split the RA process into phases. At the completion of a phase within the RA, the equipment in that phase was authorized for use, specifically for process characterization and qualification, while the RA continued for other phases. The RA was subdivided into 5 phases: facility, NT processes, analytical processes, NG processes, and tester processes.

The RA for the facility phase was completed by participating in the final inspection of the building. The purpose of this inspection was to assure the facility had been constructed to the requirements (the design). This part of the assessment was completed by the facility project manager, SNL/NM inspectors who had followed the project through construction, and users. A punch list was developed and punch list items were resolved. This phase of the RA was completed in February 1996. At the completion of this phase of the RA, 72 employees and partners were moved into office areas of the north wing of Building 870 in March 1996.

For the other RA phases, it was verified that a Preliminary Hazard Assessment had been completed and that the approach to hazard control was adequate. Measurements were made to assure correct utilities were available to each piece of equipment. Each piece of equipment was operated under the immediate supervision of the subject matter expert that had characterized the equipment at the PP or who had written the specifications for procurement. Operational Procedures were developed. There had to be at least one trained individual for each piece of equipment. Process characterization data could not be collected nor could Qualification Reports be written until after the RA was completed for a phase.

The RA for the NT process phase was completed in May 1996 and the phase for analytical processes was completed in June 1996. The RA phase that evaluated testers was completed in October 1996, while the phase that examined NG processes was completed in December 1996. Formal documentation of the RA was forwarded to DOE in December 1996, and DOE declared Building 870 acceptable for operational use in March 1997.

Production Trades Program

Production floor operators at the PP were not transferred to SNL/NM. The NT prototyping group at SNL/NM was a combination of Trades and technicians. Those who fabricated development NTs were Trades. In addition, as a prototyping capability was established at SNL/NM for NGs, Trades were utilized. SNL/NM has a labor contract with the MTC that requires work covered by the labor contract to be completed by union members. Since fabrication of prototype NTs and prototype NGs at SNL/NM was performed by union members, it was clear that operators on the production floor would also need to be union members.

Neutron tube prototyping was completed by one group within the MTC, and NG prototyping was completed by machinists, another group within the MTC. To maximize the flexibility of operators in production, a Production Trades group was identified. Representative of the two different union groups would decide which group within the MTC that Production Trades would belong to.

Previously at SNL/NM, there had been several Trades Trainee programs that used a combination of classroom and on-the-job training to qualify a union member to work at the Trades level. A skill set was compiled for production operations for NGs. To avoid excessive overhead associated with SNL/NM technical personnel teaching the classes, as was done in the Trades Trainee programs, the curriculum at TVI was examined. Classes that were commensurate with the required skill set were identified. The number of hours to be completed during the Production Trades program was approximately 50% of that needed for an Associates Degree.

An entry level set of skills was defined for one to be eligible for the Production Trades Trainee Program. The balance of the classes would be taken in the program. Sandia National Laboratories would pay for the education costs and would pay salary during class time. Credit would be given for training already completed that was in excess on the entry level requirements. The training program would take between 3 and 4 years, depending on the prior training of an applicant. After completion of the training, an individual would be obligated to remain in the production group for three years to assure recovery of the training costs. Subsequently, an adjustment was made in the required training to better align the training to the needs of NG production. The length of time required to remain in the program after becoming a Trades member of the union was shortened to 2 years.

The Production Trades program was presented to Labor Relations and upper management at SNL/NM. Adjustments were made. Formal negotiations were held with the MTC leadership. Multiple sessions were held. Negotiations with the MTC were unsuccessful. After over 18 sessions of greater than 2 hour each, an impasse was declared and SNL/NM implemented the program over the objections of the MTC leadership. Subsequently, the program has grown in number of participants and has been incorporated into MTC contract negotiations. Today, it is a well-received program with MTC support.

Piece Part Procurement

When the PP was closed in 1994, materials on-site at the PP that supported WR and development activities in the fabrication of NTs and NGs were shipped to SNL/NM. Storage space was located across Technical Area I. Administrative controls were established for WR material to comply with requirements. Suppliers that supported the PP were made available to SNL/NM for a baseline. Procedures were implemented to assure materials would be available to support qualification activities that would begin in Building 870 in mid 1996 for NTs and by early 1997 for NGs. The initial system was cumbersome and ineffective with the lead times for some special items extending out 4 years in advance.

Infrastructure Support at Sandia National Laboratories

Sandia National Laboratories was directed to use existing infrastructure where possible to avoid costly duplication. In general, that meant the new production organization would be part of SNL/NM with access to medical, protective force, library, etc. Negotiations occurred with six organizations for specific production support.

The Materials Science & Engineering Organization expressed interest in providing the analytical chemical support for incoming materials that did not contain tritium. The Production Organization at SNL/NM would establish capabilities to perform analyses on materials that contained tritium or that required measurements with quick turn around for product to move to the next operation on the production floor. Evaluation of weld geometry is an example of the later. Subject matter experts would provide materials support for production activities through formal Memorandum of Understanding (MOU) documents that defined the work to be finished and the budget to be provided for the work.

The Manufacturing Science & Technology Organization had an extensive mechanical measurement capability. This organization would make the mechanical measurements on incoming piece parts. Shipping, receiving and transportation added capabilities so they could receive, ship, and transport closed source radioactive product in support of NG production. The Experimental Mechanics/NDT Diagnostics Department would perform environmental testing of product. The Production Organization would not have to establish the capability to perform these crucial, but capital extensive, tests.

The standard facility modification process utilized throughout SNL/NM was deemed to be unacceptable in its ability to respond to production needs. A captive contractor was selected to perform facility maintenance, repair, and modifications within production. Due to the similarity of many operations within NG fabrication to those performed in the microcircuits laboratory, the same facility contractor was selected for production as was already in place for the microcircuits laboratory. This captive contractor enabled many of the changes that were required as production operations were established. The usefulness and importance of this resource cannot be overstated.

The Environment, Safety and Health (ES&H) group would matrix radiological technologists, Health Physicist, Industrial Hygienist, a safety engineer, and an environment engineer to the Production Organization for support of ES&H disciplines. Production operations enabled this support with an ES&H, Safety and Security, and facilities department. Included in this department was a matrixed member of the SNL/NM Facilities Organization and a production employee to manage Safety and Security. This approach was a key feature of the transition success.

The MOU concept has subsequently been extended to other organizations at SNL/NM using the same format utilized initially with the Materials Science & Engineering Organization.

Analytical Testing Capability

Analytical testing that is required to support NG production activities is equipment intensive and capital fund expensive. The testing falls into the areas of incoming materials, process qualification, process and subassembly evaluation, post mortem, defect analysis, and technical research support. To help control costs, production at SNL/NM did not duplicate the analytical capabilities within the Materials Science & Engineering Center for non-tritium material analyses. Production developed a stand-alone capability for materials that contained tritium.

The following interface boundary conditions were established to clearly articulate the interface between the new production activities at SNL/NM and the established Materials Science & Engineering Center. The boundary conditions were established prior to closure of the PP.

1. Production would not introduce tritium into Materials Science & Engineering Center laboratory equipment. Production would have stand-alone equipment for all analyses on materials that contained tritium. This requirement was relaxed in 2004 for research programs that would not compromise equipment in the Materials Science & Engineering Center.
2. In general, incoming materials acceptance testing would be completed by the Materials Science & Engineering Center. Specific measurements that deviated from this guideline would be negotiated on a case-by-case basis.
3. Duplicate capabilities would be established in areas like metallographic evaluations, encapsulation, and Instron pull tests, where the floor waited for results before the next production sequence step could be taken. It was not realistic to transport samples to and from the Materials Science & Engineering Center and interrupt work for other customers, particularly when the schedule was tight, the work load was random in nature, and the analyses were very repetitive in nature with little scientific merit. Further, the equipment cost to establish these duplicative capabilities was minimal.
4. The Production Organization would not use any of its analytical capabilities to compete with the Materials Science & Engineering Center for other SNL/NM work
5. The equipment in production would be made available to the Materials Science & Engineering Center to complete work on radioactive materials, as long as the analyses would not compromise the production mission.

A list of analytical equipment was prepared to assure the required breadth of capability would be established at SNL/NM. Jim Gebhart was transferred early from the PP to coordinate equipment acquisitions. Interactions occurred between Gebhart, the subject matter expert for each piece of equipment, and the vendors. It was crucial that the equipment not arrive before the building was ready for equipment installation. It was equally crucial that the equipment was operational and qualified to support process qualification activities of the NT and NG production lines. Further, analyses would be required to verify equipment functioned at SNL/NM to the same level of performance as it did before being disconnected at the PP. This task was completed to a very tight schedule, and the analytical capability was brought on-line in parallel with the beginning of NT qualification activities five months after Building 870 construction was completed.

Process Qualification and Prove-in

A subject matter expert was assigned to each process; there were about 350 processes in total. Experiments were completed to determine the repeatability and the yield for each process. The line of sight between each process and product requirements was established. Statistical analyses were performed to determine expected yields during WR fabrication. The data was combined into a Qualification Report that was approved by the appropriate Product Realization Team. Several sequential process steps that supported a common subassembly task, such as brazing a subassembly together, were combined into a single Qualification Report.

After each of the processes was qualified for the NT line, Process Prove-In product was fabricated. Final adjustments were made before validation occurred through production lots of Tool Made Samples, which were fabricated exclusively with WR qualified processes. Units were evaluated with qualified testers to assure compliance to the product requirements. Quality assessment occurred to verify formality of documentation. At the end of this process, the NT line was declared WR qualified. A similar approach was used for the NG production line.

For NGs, reliability considerations required 4 lots of WR NGs to be fabricated. Samples were pre selected randomly for destructive testing. The reliability of the NG would be demonstrated, if there were 23 functional tests with no failures or 65 functional tests with 1 failure. The production group successfully achieved the 23 functional tests with no failure. Through November 22, 2004, when this report was started, there had been over 200 functional tests without a failure.

After the successful reliability tests, NGs were placed in bonded stores in August 1999. This was 60 days ahead of the scheduled commitment date of October 1999. Placing WR NGs into bonded stores completed the Reconfiguration Project. Production of NGs had been successfully moved from the PP to SNL/NM on schedule.

Collocation of ES&H Subject Matter Experts

Production has very unique requirements, and issues that surface must be addressed correctly and quickly to assure that production down time is minimal. It is preferred that issues be anticipated and resolved with no production down time. It is also important that there are records that document compliance to regulatory requirements, since product is shipped to next assembly within the NWC. The standard paradigm at SNL/NM for ES&H support was carefully evaluated. The subject matter expertise was present, but physically located in other buildings. The typical time to respond to ES&H issues and the level of documentation at SNL/NM were deemed unacceptable for WR production. Further, it was believed that if ES&H subject matter experts were collocated with production personnel, a better understanding would exist for both the production employees and the ES&H subject matter experts. The need of production for urgency could be met without compromising regulatory requirements.

For these reasons, it was negotiated with the ES&H organization for five subject matter experts to be collocated in production space: an ES&H coordinator, a safety engineer, an industrial hygienist, a waste expert, and a health physicist. Because a health physicist and waste expert were hired from the PP, initially those positions were filled by Production Center employees. Later, the health physicist position was filled by an individual from the ES&H line organization. Over time, the work performed by the waste expert was absorbed within the responsibilities of the ES&H Coordinator.

The ES&H experts were to provide the knowledge base for all ES&H issues. They were to team with Production Center employees to assure hazards were identified, controlled, monitored, and communicated to employees. Proper documentation was prepared. Mentoring occurred to help the production employees understand what was needed and how to best meet the requirements. The design of proper engineering controls, storage and flow of chemicals, RA, Radiation Work Permits, and implementation of the Preliminary Hazard Screening processes are areas that benefited greatly by collocation.

Facility/Equipment Maintenance

The Production Organization would never be able to have a standard throughput to meet delivery requirements, if facility and/or equipment repairs did not occur rapidly. Sandia National Laboratories did not have an existing organization that performed equipment maintenance. Further, it would not be expected that the specific knowledge base for production equipment would be resident within the generic services available within the Laboratory. Hence, an equipment calibration and maintenance group was established within the Production Center to address equipment maintenance, repair, and calibration.

If the Production Center was to avoid duplicative infrastructure, a boundary condition established by the Reconfiguration Project, production needed to use the existing facility infrastructure. Production would not be responsible for site-wide requirements, like the ten-year facility site plan. But, the typical response time for facilities to resolve issues throughout the Laboratories was unacceptable to the production organization.

Negotiations were conducted over a couple of years to finalize the relationship that needed to exist between the Facilities Organization and the Production Organization. A building manager from the Facilities group was provided office space within production facilities. The building manager would coordinate all facility modifications and all facility repairs within buildings that supported production. The building manager would become familiar with production obligations, including delivery schedules. Facility modifications would be coordinated around critical milestones. Facility modification work must be coordinated with the production floor to minimize negative impact to the floor. Extensive measures would be taken to control generation of particulate, so product performance would not be impacted by building modification activities.

The facility organization would not be able to respond to the needs of production, if they used the existing response mechanism. The Materials Development Laboratory, and its predecessor that had manufactured hardened microcircuits at SNL/NM, had learned over time that the only way the production operation requests for facility repair and modification could be met was through a captive contractor. Neutron generator production adopted this model and negotiated for facilities to manage the contract. A captive set of contract facility personnel was dedicated to, and paid for, by the Production Organization. The needs of the Production Organization drove the schedule and adjustments to the schedule. A teaming relationship was established. The contract maintenance personnel became familiar with production needs. Major repairs or modifications were completed over the winter break, or were staggered in a way to have minimal impact on day-to-day production operations.

To address the long-term evolving facility needs, it was negotiated with facilities and the SNL budget managers that production would receive approximately $3 million of funds annually in the GPP area. These funds would be used for new building construction, major renovations, and modification of space assigned to production. Anticipated projects were identified in the ten-year site plan. At times, specific items were shifted forward or backward to accommodate emerging needs of higher or lower priority.

Information Technologies

During start-up activities, it was decided to strongly couple the Information Technologies activities of the Production Organization with Corporate Information Technologies. Production needed to be integrated into SNL/NM activities, not to establish an independent self-contained approach to information and its associated technologies. Communication would be improved, and costs would be significantly reduced through integration. To facilitate the commonality of Information Technologies within production and the Laboratories at large, Corporate Information Technology personnel were collocated with production personnel. A partnership was established. One goal of the partnership and collocation was to develop a common understanding of the needs of each. This approach has been very successful.

Production/Development Use Same Equipment on Same Floor Space

Initially it was anticipated that the capacity of production facilities at SNL/NM would be about 600 units a year, 500 units of WR product and 100 units for development. It was believed that development and production could use the same equipment and occupy the same floor space. This approach significantly reduced the capital outlay of the Reconfiguration Program.

When the capacity requirement was increased to about 1500 units a year, it became clear this approach would not work. The flexibility required during process development and experimentation is diametrically opposite to the formality of operations required for production. Further, one-piece-part flow and a pull approach to production is not amendable to scheduling development activities that would disrupt flow and which might remove equipment from its qualified condition. Experimental projects could require equipment configuration changes and might request experimental parameters outside of those qualified for the equipment. Conversion back and forth would consume valuable time on the equipment and would significantly reduce availability of the equipment for both production and development. Additionally, the sequence of development is not always easily predicted and the needs of production would limit availability of equipment, significantly increasing the time to complete experiments.

During start-up activities, three points were made by an industry advisory board. The experience of industry was that development and production needed to be performed on separate pieces of equipment in different space, though the equipment for development needed to be the same as that which would be used in production.

Initially, production at SNL/NM was constrained to the model (same equipment on the same floor space for development and production). This constraint continued for NTs until equipment was procured and installed in Building 700 by August 2002. The equipment for NTs was qualified for operation by March 2003. This model continued for NGs until Phase II of Building 700 was completed in August 2003. There was a transition for NGs from the production floor to Building 700 during 2004.

In conclusion, it was a bad decision to collocate production and development on the same equipment in the same space. Production and development are intrinsically different activities with diametrically opposite drivers for success. Production and development should have separate equipment and different floor space to the greatest extent possible. However, the equipment should be identical, or at least functionally identical, to minimize duplicative development activities during the transition of product from development to production.

Production Staging Space

Building 870 was designed and constructed to accommodate the required operations to fabricate WR NGs. No free space for staging of new equipment was included. No free space was allowed for future manufacturing changes. When GPP funds became available at SNL in 1996, the lack of flexibility in Building 870 was addressed through the design of Building 700, Phase I. Construction of Building 700 Phase I was completed in the summer of 1997. Building 700 was utilized during the Rapid Reactivation Project to support WR fabrication of NTs.

SUBSEQUENT IMPROVEMENTS

The previous section, “Start-up Activities at Sandia National Laboratories,” discussed efforts to establish a capability to fabricate WR NGs at SNL/NM. This section addresses areas of focus that realized significant improvements subsequent to having established a basic WR production capability. The only exception is the next section that discusses the Rapid Reactivation Project that was completed in parallel to WR qualification efforts in 1998 and 1999.

Rapid Reactivation

Early in 1995 during the construction of Building 870, it became apparent that the design basis of Building 870 (600 units a year) was inadequate to support the number of units actually needed. The design basis of 600 units a year supported the Active Reserve but did not consider the Inactive Reserve. As Building 870 was nearing completion of the construction phase, a Conceptual Design was developed to support a larger delivery capacity of about 1600 units a year. Modifications would be required in both the NT and the NG production lines. A Baseline Change proposal to the Reconfiguration Project was submitted. Authorization and funding were requested to modify Building 870 and to procure equipment to increase the production capacity to 1600 units a year. The modifications could have been implemented during equipment installation and before WR qualification began. The Baseline Change proposal was denied.

In 1997 the Rapid Reactivation Project was submitted again. It was not rejected, but it was postponed. In 1998 it was recognized that eventually an increase in capacity for production at SNL/NM above the design basis of Building 870 of 600 units a year would be required, but a hiatus in the ability to fabricate either NTs or NGs was an unacceptable risk. Hence, the modifications would have to be completed during qualification and/or production activities. The Conceptual Design produced in 1996 was no longer applicable, because at least a 6 month stoppage of NG fabrication would have been required to modify the ventilation systems in NG space in Building 870. Permission was received to reevaluate the initial CDR and consider other alternatives. This re-evaluation of the CDR determined that a separate facility (Building 857B) would need to be constructed for NG fabrication, and the NG production line would have to be moved from Building 870 to this new space.

A NEPA checklist was prepared, and DOE notified SNL/NM that an EA would be required before SNL/NM could implement steps to increase its production capacity. The EA for Reconfiguration did not address the larger capacity. The EA for the increased capacity option began in August 1998 and was submitted for public comment in December 1998. A Finding of No Significant Impact was published late January 1999.

On October 6, 1998, a briefing was made to DOE Headquarters regarding the need for increased capacity at SNL/NM. The Rapid Reactivation Project needed to be authorized for implementation immediately after the NEPA process was completed. DOE agreed, and the project was authorized in February 1999.

The Rapid Reactivation Project began a red project, because its end date was held firm but the start date had slipped 2 months from December 1998 to February 1999. The project was to be finished by January 2002. Upon authorization, two activities began in parallel. During February and March definitive plans were put into place to modify Building 870 for increased capacity on the NT line, including acquisition of new equipment. The East Annex of Building 870 was the most difficult, because ongoing WR NT fabrication had to continue during the modifications without compromising NT quality.

A sequence of room modifications was identified for the East Annex and for the balance of the NT fabrication line in Building 870. WR cleaning and plating were moved from the East Annex of Building 870 to Building 700. The vacated space was modified and prepared for its final function at higher capacity. New and existing equipment were installed and proven in. This sequence was repeated within the newly created open space. A similar process was followed in the main wing of Building 870. Construction barriers were used to control debris generation. Building exhaust system and other infrastructure changes occurred over the Winter Break 1999.

Production schedules were coordinated with room modification and process prove-in. Monitoring in production space and in adjacent space occurred to detect particulate contamination build-up. Regular debris clean-up occurred to assure that contamination was not introduced into the product, because the product is very susceptible to particulate contamination. Due to these stringent controls, product yield did not decrease during the construction phase of the Reconfiguration Project. This was contrary to prior production experience at the PP, where decreased yield was always observed when building modifications occurred anywhere in the production plant.

Design of Building 857B began in February 1999 and was finished November 1999. A contract was in place for construction to begin in March 2000. The construction phase of the contract was shortened a month to recover 1 month of the initial project delay. Movement of a steam line caused another delay, which was recovered by shortening the construction phase another month. Hence, the construction of Building 857B was shortened from 12 months to 10 months (one month to order materials and 9 months to complete the construction), and was scheduled to be completed in January 2001.

In August 2000, a request was received to accelerate the construction phase to support the qualification of the MC4368A NG. To respond to the request, much of the production line would need to be moved over the Winter Break 2000, so qualification could occur by May 2001. A change to the contract was put into place and the construction of Building 857B was completed before Winter Break 2000. The MC4368A was qualified in it new location by April 2001.

With this additional pull up of the construction phase, the project was completed on time without shutting down the NG production line. Yields were not negatively impacted. The project plan included the amount of time that was required to move and re-qualify processes. Adjustments were made to the project plan as required to respond to production floor needs. Similarly, the production floor accommodated the facility modification needs to allow the project to stay on schedule.

Memorandums of Understanding

As the funding structure to support production at SNL/NM was established, a small amount of funding was given to production that production could use to support research and development throughout the Laboratories. This was a change in paradigm with very positive results. Dialogue between researchers and end users about technical information was beneficial to both the researcher and production personnel. Specific objectives defined by production established constraints that assured the relevance of the research, and the research had an immediate application. As production gained fundamental knowledge, better judgments were made with concomitant results of higher yields. Production and researchers gained insight about critical attributes that had to be controlled to assure specifications were met.

This new approach provided a technical basis for process control in preference to testing product to assure quality. Once critical attributes were known, with fundamental knowledge to support the selection of critical attributes, production became more agile. The effect of a failed furnace, for example, could be assessed against critical attributes to determine if product was salvageable or if the materials had to be scrapped.

To this end, MOUs were developed with research and engineering organizations across SNL/NM. Short term and long term objectives were developed collaboratively by the research/engineering organizations and production. Budgets commensurate with the level of effort were established. Experimental results were presented to both the technical community and production for peer review. This approach was a significant contributor to production increasing process yields to greater than 90%.

An example of an early success within the MOU program was that of thermal modeling of the MC4277 NT exhaust process. The modeling identified geometric relationships between the tube and the furnace. The range of variance in position of the tube that did not affect the exhaust process simplified mounting constraints. Further, once the exhaust process was modeled and validated for the MC4277, the modeling was extended to the MC4300 NT. Experimental efforts for the MC4300 NT were greatly reduced, and qualification efforts for the exhaust process for the MC4300 NT were simplified. Qualification activities for the MC4300 tube were more of a validation than a development effort.

Burning Platform

During 1998, our customer, the DOE, refined future delivery requirements. The new requirements clarified that the production capacity for NGs needed to accommodate a future annual production rate of 1500 NGs per year by approximately 2008. The original design goal for production at SNL/NM had been approximately 600 NGs per year. A study was initiated to assess the current capacity and to determine what additional equipment and floor space was required to satisfy this new goal. The Rapid Reactivation project, already discussed in the Section, was implemented to address the equipment capacity shortfall.

Prior to the Rapid Reactivation Project, a single shift had the capacity of approximately 600 to 700 NG per year. The Rapid Reactivation Project provided the equipment and facility capacity for 1500 NGs a year, but to attain an operational capacity of 1500 NGs it would have required approximately 30 (+55%) additional production operators. Second and third shifts would have to be implemented to address bottlenecks. Operational budget for increased staffing was not provided.

Ship requirement schedules were updated periodically throughout 1999 and 2000. The peak production demand continued to show a future peak year requirement of 1400 to 1500 NG per year. Attempts to obtain a commitment for out-year funding for the 30 additional production operators were unsuccessful. The leadership of the Production Center concluded it would be necessary to apply creative techniques to improve the overall efficiency of the production operations.

This dichotomy between available production operators and the number required to meet delivery requirements became the "burning platform." A number of alternatives were evaluated, and the Lean/Six Sigma approach was selected.

Selection and Implementation of Lean/Six Sigma

In November 2001, the production leadership team made the commitment to implement "Lean Thinking" approaches to improving the capacity with existing levels of production operators. The manager of production was assigned the lead role. A carefully-selected group of employees were given Green Belt and Black Belt training. These employees were to learn the lean/six sigma approach and then were to lead the rest of the organization to operational success. The goal was established that all members of the Neutron Generator Production Center would take a five day Green Belt training class. Managers in discussion with employees would determine who would become a certified Green Belt by completing an appropriate project that led the organization towards increased operational capacity. In 2005 it became a requirement for employees in the Neutron Generator Production Center to take Green Belt training.

Early in the implementation process, the Management Team received several focused training sessions on the concepts of lean and six sigma. Waste was to be identified and eliminated. The flow time for major subassemblies was identified and tracked. Initial lean events received a high management priority. Those who completed Green Belt training and those who became Green Belt Certified were recognized. Incentives were built into the Labor Contract to encourage union employees to become engaged.

A concentrated effort was placed on implementing a workplace organizational methodology (6S) on the production floor in existing work cells. There was a reduction in cycle time. Standardization and elimination of clutter in work cells had a positive psychological impact in addition to the reduction in cycle time. A major Kaizen event was conducted to implement pull production in the final assembly and test portion of the NT production line. This project promoted a major design project for a new compact work cell, involving the procurement of new and more efficient process equipment, significant improvements in the reduction of hands-on process time, and a major reduction in queue times. This project was recognized through a Corporate Award for process improvement.

In 2003, the Management Team restructured the organization into Product Value Streams and support departments. Each Value Stream was responsible for, and had the resources to support, their success. One focus within each Value Stream was to identify and eliminate waste. Another result was the selection of pull for the production of NGs. Each event had two principal purposes: identify and eliminate waste resulting in reduced cycle time, and teach/train the production organization in lean/six sigma principles.

In parallel with implementing lean principles, significant emphasis was placed on process characterization. This effort improved the manufacturability of NGs and increased process yields. Emphasis was given to processes that had yields below 90%. By 2006, all process yields were above 90%.

In early 2005, the single shift capacity of the production operation was assessed to be approximately 1000 NG per year, almost double was it was in 2001 when lean/six sigma was selected. This improvement in capacity was due to a combination of the “learning curve effect,” improvements in process yields, implementation of lean improvements and pull production. Additional production operators were not hired; the production organization was doing more without increasing floor operators. This increased efficiency resulted in an annual savings of more than $3.6 million in labor costs.

The organization has three more years to make additional improvements to achieve the production demand of 1500 NGs by 2008 without adding production operators. The approach will be to continue to apply lean principles and pull production in all manufacturing operations. Processes with low yields will be improved through process improvements.

Information Technologies

Early in the partnership with Corporate Information Technologies, an enterprise resource planning process was implemented. A focus of this effort was to use commercial off the shelf (COTS) software. The use of COTS precludes unique specialization within production with its concomitant isolation and expensive overhead maintenance costs. An output of this strategy was to implement TXBASE in a 100% COTS mode with no customizations. The Production Center adopted a strong emphasis on industry standard business practices (i.e. inventory control and planning) which allowed production activities to use COTS software as received from the supplier without customization. It was difficult to convince users that software could be used without customization, because this was an approach contrary to the culture of most employees in the Production Center. Successful implementation of COTS allowed the Production Center to take advantage of commercial software upgrades without the expense of developing and testing upgrades internally. A strong relationship was established with the suppliers of the software, and the suppliers carefully considered recommendations from the Production Center.

The partnership established with Corporate Information Technologies was validated when the Production Center was asked to take the lead when SNL implemented Oracle Enterprise Resource Planning. The request was a direct result of the Production Center’s success in implementing

TXBASE. The Production Center was the initial and principal user of the Oracle system for the first year. Through this interaction, production needs became well-understood by Corporate Information Technologies personnel, a benefit that came back to production in the form of having access to additional technical resources to address internal problems and unique challenges. Production also received more software than had been available to them before. SNL learned from our example and experience.

Materials Management

Introduction

When the PP was closed in 1994, materials on-site at the PP that supported WR and development activities in the fabrication of NTs and NGs were shipped to SNL/NM. Storage space was located across Technical Area I and administrative controls were established to comply with WR requirements. Suppliers that supported the PP were made available to SNL/NM as a baseline. Procedures were implemented to assure materials would be available to support qualification activities that would begin in Building 870 in mid 1996 for NTs and by early 1997 for NGs. The initial system was cumbersome and ineffective with the lead time for some items exceeding 4 years.

In 2000, the organization recognized the need to address inadequacies in managing the supply chain. A Material Value Stream (MVS) was organized to address the inadequacies of the piece part procurement system and the infrastructure of the MVS organization. The MVS is integrated with the production value stream, creating a line of sight to their goals and objectives. The MVS has responsibilities in three main areas. The Purchase Material Team is responsible for the engineering, planning and procurement of raw materials required to support the master production schedule. Within the Purchase Materials Team, Purchase Material Engineers are responsible for item drawings, acceptance requirements and the technical liaison with design engineers, product engineers, production operators, and suppliers.   The Tool Team is responsible for tool design and the fabrication of tools, gages, fixtures and molds to meet specifications. The Materials Management Team is responsible logistic services, shop supplies management, equipment spare parts management, and shipment of production material and finished goods.

The MVS has embraced world-class/lean manufacturing practices, developing and implementing an infrastructure of standard processes with documented procedures. Performance metrics are used to drive improvement and to measure success. All facets of the MVS strive to support the department mantra of “quality parts, delivery on time, at the lowest cost with maximum agility.” Specific MVS initiatives addressed include: integration with Procurement, Value Stream Mapping, Standards and Discipline, Supplier Metrics, Reduction of Inspection Waste for Incoming Materials, Supplier Conference, Upfront Drawing Reviews, and New Production Warehouse. Each of these areas is briefly described below.

Integration with Procurement

The Production Center took steps to identify and integrate key support functions to ensure mission success, within the MVS one of these key functions is procurement. A matrixed model was utilized such that procurement contracting representatives are collocated with the MVS staff. The contracting personnel are key members of the different teams within the MVS and participate in weekly team meetings and in lean events. Contracting personnel help establish goals, and they champion improvement initiatives. This inclusion helps the contracting representatives to gain a true understanding of the operations and the needs of the Production Center. Together, acquisition planning and post-contract placement administration were improved.

Value Stream Mapping

Value Stream Mapping has become a crucial technique for driving improvements within the MVS. The current state is carefully compared to the preferred future state. Internal inefficiencies and waste are identified and a planned path forward is developed to enhance organizational effectiveness. One example is highlighted to demonstrate the benefit of this approach. The value stream mapping process highlighted a major difference in span time for the two procurement methods used within manufacturing. The traditional procurement process utilized for approximately 70% of the purchase orders had a span time of 25 days. In comparison, the Just in Time contract used for acquisition of chemicals had a span time of 4 days. Changes were implemented to create a Just in Time like procurement process for all mechanical parts. A 5-year agreement was established with two suppliers to support the acquisition of more than 75 machined, Electrical Discharge Machined, and Electrical Discharge Machined formed parts. This novel approach decreased the span time for these parts from 25 days to less than 5 days. These two contracts also resulted in a lead-time reduction for all mechanical parts from an average of 11 weeks to 8 weeks.

Standards and Discipline

Widespread implementation of the lean/six sigma methodology known as 6S (sort, straighten, shine, standardize, sustain, and safety) on the production floor identified the need to improve ordering, replenishing and general management of shop supplies. The 6S implementations uncovered several issues—excessive quantities of shop supplies located in multiple storage cabinets and at individual workstations and inventories of items no longer used in production. The process also highlighted excessive travel time of operators to obtain the needed supplies and lack of a process to ensure needed supplies were replenished on a timely and consistent basis.

To address these inefficiencies, overall management of shop supplies were integrated within the MVS. Visual supply Kanbans were established at strategic locations on the production floor, and a process for monitoring the Kanbans 2-3 times a week was established. Shop supplies have been standardized across multiple production entities, where possible, and a consolidated inventory of shop supplies are kept in a warehouse. Existing Just in Time contracts are used to ensure the effectiveness of the procurement process. Excess shop supplies have been eliminated on the production floor, and the amount of floor space required to store shop supplies on the production floor has been reduced. This approach has been beneficially used by other production activities at SNL/NM.

Supplier Metrics

To effectively manage and improve the materials supply chain, the use of supplier metrics continues to be a primary focus of the MVS. In 2001 supplier performance metrics in the area of quality and delivery were defined and communicated. As a result of the published expectations, percent part accepted increased from 85% in 2002, and has been sustained at, 95% even with the addition of many new suppliers and parts. Supplier delivery reports measure the parts arriving in the "on-time" delivery window (10 days early to 3 days late) relative to the promise date per the purchase order. Delivery performance has increased significantly from less than 40% in 2001 to consistently above 80% since 2003.

Reduction of Inspection Waste for Incoming Materials

Embracing lean/six sigma is the catalyst for the MVS efforts to reduce inspection, one of the most obvious forms of waste. Three key initiates to reduce inspection waste include the implementation of a Purchase Material Acceptance Application, PMAA, strategies to reduce chemical inspection, and implementation of acceptance gauges. Each of these initiatives will be briefly discussed.

Purchased Material Acceptance Application (PMAA): PMAA is a web-based application that increases efficiency, decreases costs, and mistake-proofs receiving, inspection, and non-conformance of incoming production materials. Bases on historical data, PMAA employs statistics to determine when inspections are necessary. The reduction in inspections is done strategically to assure overall material quality is sustained. The integrated solutions allow the concept to be implemented efficiently and consistently across all incoming material lots. The system has not only improved our internal process, reductions in inspection cycle time provides timely feedback to suppliers that allow them to improve their processes providing SNL/NM high quality product at lower cost and shorter lead time.

Purchases Material Acceptance Application, Phase I, implementation in 2002 resulted in chemical inspections being reduced by 72% and mechanical inspections by 40%. These reductions have been sustained since 2003. The overall cost of inspection was reduced by $400k, from $1.5m to $1.1m from 2002 to 2004. Purchased Material Acceptance Application Phase II was implemented in 2004 and focused on reducing the number of transactions and on mistake proofing. The enhanced system resulted in an additional $200k reduction in inspection costs.

In 2005 a third phase of the PMAA program was implemented, which integrated external mechanical inspection suppliers into the supply chain. A long-term contract was established with suppliers which solidified a partnership that allowed us to grant them assess to SNL's internal network. With access to the network and software enhancements implemented in PMAA Phase III, the inspectors at the supplier can directly access and enter inspection data into SNL's system. This will reduce the cost of inspection by an addition $200k-$300k a year and help SNL/NM production achieve a dock to stock cycle time of less than 3 weeks.

Reduction of Chemical Inspection: In 2002, the average cost of chemical inspection was three times the value of the material. Two significant strategies were implemented to reduce the cost of inspection. For chemicals manufactured in large homogeneous batches, vendor-managed inventory was implemented so fewer inspections were required for material acceptance. This resulted in a slightly higher material cost, yet the total acquisition cost was decreased. In conjunction, the approach for managing limited life material was also changed. When it is cost advantageous, new material is procured rather than to retest old material. These two changes resulted in a cost reduction for chemical inspection from $550k to $340k annually.

Inspection Reduction through Acceptance gauges: For some difficult to inspect parts, gauges were developed to check dimensional requirements more simply and accurately. These gauges have been deployed to supplier locations allowing the supplier to check the parts prior to shipping. Gauging of parts by the supplier provides immediate feedback to suppliers and ensures 100% good parts are shipped to SNL/NM. Two examples are noted. A complex machined metal component, the base plate, is required by drawing definition to be 100% inspected for critical features. A source inspection gauge was created and deployed at the supplier with the following results. Acquisition cost per lot was reduced by 30%, inspection cost was reduced by 50% per part, and cycle time for acceptance was reduced from 6 weeks to less than 2 days. When a source inspection gauge was implemented at the supplier for a complex formed metal component, similar results were obtained. The percent part acceptance increased from 30% to 100%, with similar improvements in cost and cycle time.

Supplier Conference

Suppliers and their products/services constitute a significant portion of the cost of NTs and NGs. To be successful the Production Center must develop and maintain partnerships with suppliers. Due to the high complexity requirements of the product and inherently low volumes, selecting the right supplier and managing the relationship is critical to mission success. To this end, a production Supplier Conference is held each year. The central theme of the conference is to acknowledge the efforts of suppliers in providing exceptional quality and delivery performance for the preceding year. Further, the conference provides information about the NWC, the production environment at SNL/NM, and challenges associated with the production of weapons components. The conference serves as a springboard for communicating the lean journey of production at SNL/NM through presentation of lean manufacturing concepts and inviting the suppliers to join production's commitment to continuous improvement through lean manufacturing practices.

The Supplier Conference brings together supplier representative, SNL/NM design and production engineers, contracting representatives, managers and lean practitioners. The Supplier Conference objectives are met through formal presentations, networking breaks, and dinners. Expectations for the coming year are presented. The most improved supplier from the previous year is invited to share their success with emphasis on the steps they took to achieve the improvement. Additionally, rewards are presented in open forum to recognize outstanding performance by the suppliers.

In 2002 the Oro Award (gold) recognized 95% quality and 95% on-time delivery, and the Plata Award (silver) recognized 90% quality and 90% on-time delivery. Three Oro Awards and four Plata Awards were given. In 2005, the requirements for an Oro Award were increased from 95% to 98% and the Plata Award was increased from 90% to 95%. Despite raising the requirements, fifteen suppliers received the Oro Award and one supplier received the Plata Award.

The Supplier Conference has achieved its major objective of establishing and maintaining a cooperative relationship with SNL/NM's suppliers. Participation by suppliers has increased from 45 attendees in 2002 to 150 attendees in 2005.

Upfront Drawing Reviews

To reduce the risk of procuring and/or receiving unnecessary or incorrect material, an upfront drawing review was instituted prior to order placement for each item destined for production. Communication is facilitated among SNL/NM product engineers, purchased material engineers and suppliers. A Purchase Material Engineer verifies that the drawing is complete and that the product can be manufactured. Based on critical requirements a supplier is selected that is a good match for the part. Communication occurs with the supplier to resolve technical issues and to address manufacturing concerns. The acceptance criteria are established prior to placement of a purchase order, and inspection methods are examined to assure the supplier is capable and sufficient. A check of the data systems is completed to verify necessary information exists and is up-to-date so the materials supply chain from customer request through delivery flows seamlessly. The output of the Upfront Review is shared with the product engineer and buyer to assure a clear and common understanding of the requirements. This early engagement has resulted in improved designs and enhanced partnerships with suppliers.

New Production Warehouse

In the fall of 2005 construction of a 20,000 square foot production warehouse and supporting office space was completed. The new building was designed to meet production warehouse and material handling requirements (except storage of explosive materials), spare parts for calibration and maintenance of equipment, and back-up tooling fixtures, gauges and molds. The warehouse consolidated operations which had previously been housed in 9 different facilities. The facility also houses the production records center.

Capabilities were designed into the Production Warehouse to safely store chemicals, radioactive materials, classified materials and precious metals. These items are moved to the production floor as needed. Movement of explosives is also coordinated from the building. Access control assures the integrity of mark quality material. Purchase material engineers, tooling engineers, materials planners, buyers, warehouse operations staff, administrative support staff, and management are collocated in the office space. Benefits of collocation include: enhanced communication among team members, facilitated development and implementation of standard work, elimination of waste (excess travel time and rework), and enhanced organizational efficiency. Additional mission assignments have been accepted with no additional staff.

Conclusions

The decision to close the PP and move the NG production mission assignment to SNL/NM in 1994 provided many new challenges and opportunities in the area of materials management. In 2000 the Production Center recognized the need to establish and implement an infrastructure to effectively manage the material supply chain, if it was to achieve manufacturing excellence. Strategic management of suppliers, including building and maintaining effective partnerships, was needed to improve supplier quality, delivery and long lead items. To meet this challenge the MVS has embraced world-class/lean manufacturing practices, developed and implemented an infrastructure of standard processes with documented procedures. The MVS has demonstrated significant improvement in cost and span time and has established a standard for using performance metrics to eliminate waste, drive operational improvement and measure success. Lean principles have been foundational for the progress to date and will continue to provide the tools and methodologies necessary to the support of the MVS's commitment to "quality parts, delivery on time, at the lowest cost with maximum agility."

ESTABLISHING A CULTURE

Background

When production was moved from the PP to SNL/NM, there was a mixture of backgrounds within the personnel of the Production Center at SNL/NM. Approximately 83 individuals were transferred from the PP during the 1994-1996 calendar years. These consisted of managers, technical staff, and technicians. Most of the engineers and technologists in this group had worked more in development than on the production floor. Managers from the production floor brought manufacturing experience. No floor operators were transferred to SNL/NM.

At the start of the transfer process, a similar number of employees came from SNL/NM. The SNL/NM employees consisted of managers, technical staff, administrative staff, technologists, administrative staff associates, office administrative assistants, and employees represented by the Metal Trades Counsel. Some of these individuals had worked with production from a distance but had limited actual manufacturing experience. These employees brought a background of research and development and a familiarity with the broader SNL/NM community.

By the time process qualification began in 1996, a significant number of employees had been hired from the private sector. When the first NGs were put into bonded stores in August of 1999, additional employees had been hired from the private sector. Those hired from the private sector had manufacturing experience. At the beginning of 2000, the mixture of employees was nearly 40% from the PP, 35% from SNL/NM, and 25% from the private sector.

The mixture of PP, SNL/NM, and private sector employees created a culture challenge that had to be addressed. The natural tendencies of the three different groups were different, and sometimes diametrically opposite. The economic bottom line did not receive the same emphasis within the NWC as it did in private industry. Formalization of operations is crucial to assure quality within the NWC. Within the NWC, a successful approach was duplicated the same way every time. When significant changes occurred, the production line was re-qualified. The formal approach and the resistance to change found in manufacturing within the NWC were foreign to a research background, and even to private sector experience. Process and technical understanding was not always part of the manufacturing background.

In the following sections, topics are addressed that contributed to the development of the production culture that exists within the Production Center. The topics are not intended to be all-inclusive, but are intended to be illustrative of challenges that contributed to the development of the production culture at SNL/NM. The culture that was developed is significantly different from each of the three sources of employees (PP, SNL/NM, and private sector), yet contributions came from each of the three groups of employees.

Conflicts

The divergence of background and differences in the way the three groups approached technical challenges, schedule, and cost produced incidental and severe conflicts amongst the personnel within the Production Center. A number of different approaches were taken to mold the three different backgrounds into a production culture at SNL/NM. Strategic planning sessions were conducted with the management team. Off-site workshops for groups, and on one occasion for the entire Production Center, legitimized the differences. Employees were encouraged to value the differences, to explore different approaches, and to develop a unique culture for production within a National Laboratory.

A number of meetings were held to define the desired culture for a manufacturing enterprise and the present state. Attempts to implement the desired end-state culture were ineffective. More success occurred after the decision was made to accept the existing state and to take steps to move from the present to the desired. The creation of a mind map, which defined the end state, clearly identified communication as a crucial part of moving forward. The same words meant different things to those with different backgrounds. Once a common understanding existed, progress was more apparent.

The production culture solidified after the burning platform was recognized and acknowledged, and lean/six sigma was selected as the path forward. The adoption of a common approach, which was different than the natural tendency of each of the three groups of employees, provided a common thread around which everyone could rally.

Separate Development/Production Equipment and Space

In the beginning development and production used the same equipment and space. This produced significant tension and severe conflict. After the decision was made to remove development activities from the production floor, and after space and equipment was made available to NT and NG development in Building 700, it was much easier for the entire organization to support development and production. Competition for resources and resolution of which activity had the higher priority became dialogues rather than entrenched debates. Eliminating this source of conflict had monumental impact on establishing a culture within the Production Center. Everyone could pull together rather than posture for the highest priority position.

Approach to Quality

When production was established at SNL/NM, a different model was adopted for quality assurance. Instead of having a large infrastructure of personnel who monitored the quality of processes and product, the decision was made that operators would track and document compliance of processes and product to design specifications. Process control was utilized in preference to testing after product was fabricated to verify compliance to requirements. This approach is unique in the NWC and contributed to cost reductions and increased production floor efficiency. Teaming occurred with the National Nuclear Security Administration (NNSA) to eliminate formal product acceptance processes when product acceptance did not add value.

Collocation

A different approach was taken for critical partners; they were collocated within production space. The groups identified that would benefit most from collocation were: ES&H subject matter experts, facility building manager, and procurement. After Building 700 was completed, collocation of the MC4300 development team (design and production) helped the team meet its development activities and the delivery schedule. Unique interesting teaming relationships were established. The ES&H professionals helped the Production Center to comply with requirements, but with an understanding of the pressures that existed within production. The building manager for production buildings gained an appreciation of production schedules, and the facility methodology was to find an approach for facility modification that did not compromise either the production schedule or product quality. Procurement was no longer separated from production floor needs. The increased understanding of critical partners to production needs helped production achieve its goals and objectives.

Utilization of Laboratory Capabilities

The focus of SNL/NM is to understand fundamental aspects relative to its nuclear weapons responsibilities. Researchers across the laboratory are interested in helping production succeed, but are not interested in being involved in day-to-day production activities. As new technology is developed, it is a natural desire of researchers that production incorporate the new technology into it products. This is a technology push concept, and does not meet the needs of the production. Yet, production has a tendency to never want to change anything that works. If it works now, leave it alone. A teaming relationship was developed over several years where production funds were channeled to research groups. Researchers were encouraged to use their capabilities to understand production issues. The application of the research was clearly defined. This approach produced a significant improvement, and benefits came to the Production Center through more reliable processes with concomitant increases in yields. Technology was incorporated when it was meritorious, not because it existed.

Captive Facility Maintenance and Repair Contractor

It was recognized early that the timeframe for facility modifications across SNL/NM were unacceptable for production activities; hence, a captive contract for facility maintenance and repair was established. The contract has always been managed by the Facilities Organization with funding from the Production Center. The captive maintenance personnel understand production schedule demands. Production floor personnel make adjustments to accommodate facility modifications that have to be made. Approaches were developed that allowed production and facility modifications to occur in adjacent space without negative impact on product quality.

Design/Production Interface

The role between production and design had to be explored and understood. Changes were identified and implemented. Initially, production and design were part of the same organization. Then, design was removed to accommodate a perception that separation was required between oversight and implementation responsibilities. Additionally, it was explored to determine if production should be removed from SNL, to be managed by a contractor, for example. Much time and anguish occurred, primarily within those who initially had been SNL employees, regarding potential separation from SNL. No clean split between production and SNL was identified, because of the commonality of infrastructure. Further, separation of NG production from SNL would result in increased infrastructure costs within the NWC at a time when overall NWC costs must be reduced. Higher management at SNL/NM recognized that production was a SNL mission, and the political motivation to separate production from SNL was eliminated. Finally, production and design departments have been brought back together into the same organization with the potential of realizing additional cost savings.

It took the burning platform for production at SNL to realize that the approach being used would not result in success. Production needed a "can do" attitude, and additionally, production needed to do things differently. The organization embraced the lean/six sigma approach. Small successes were used to leverage broader effects.

Command Media Evolution

As a production capability was established at SNL/NM, it was believed that a hierarchy of documents must be in place to assure design requirement were met, that quality principles were followed, and that conduct of operations were well-defined and implemented. This is a correct concept, but initially an extensive and burdensome set of documents were prepared. The operational documents were very detailed. It was essentially impossible for an individual to have a complete grasp of the command media; hence, many documents existed that were not followed. Several years into the manufacturing effort, an examination was made of the command media. The documents were sorted into categories—what was required, what was training, what was helpful, and what was waste? Elimination and simplification occurred. Documents that had not been updated, because they were not used, were eliminated. Other documents were simplified and were reduced to the required information to assure compliance to requirements. Training was either removed or was kept in the document as a buried text for the untrained. The experienced operators did not need the training information to assure operations were performed correctly. A more compact set of command media evolved.

Infrastructure Implementation

In general, infrastructure is defined as the supporting activities required for an organization to realize its deliverables. Infrastructure falls into both business practices and technical areas. The Reconfiguration Project was based on the premise that production at SNL/NM would utilize existing infrastructure capabilities at SNL rather than have a stand-alone capability. Examples of existing infrastructure at SNL that were not to be duplicated include: security, medical, library, facilities, shipping and receiving, procurement, and payroll. When the existing infrastructure within SNL did not totally meet production requirements, teaming relationships were developed to address those needs. Examples of the teaming areas include facility maintenance, ES&H subject matter experts, procurement, research and development, information technologies, and analysis of materials that do not contain tritium. In areas where the capability did not exist within SNL, production established stand-alone capabilities. Examples of stand-alone activities are materials management, analysis of materials containing tritium, record of assembly documentation, and delivery of product.

The approach to infrastructure needs of the production organization was generalized and is provided here, because it is a critical part of the production culture that was developed. In general, a four-step approach was utilized: define the process, understand the needs, form a team (or teams), and implement activities to meet the needs. A variety of techniques were used to define a process. These included brainstorming, project plan mapping, vertical values stream planning, and technical reviews. The output was a flowchart that included the steps to produce the deliverables and identification of the responsible individual(s). The identification of needs came from an examination of the output, including relevant requirements, and the methodologies utilized to produce the output. Design specifications, general procedures, objectives, metrics, information systems, and expertise of personnel were evaluated. These evaluations identified gaps that had to be addressed. A team (or teams) was formed to implement the process. Makeup of the team assured the depth and breadth required for success.

To assure that the first NG would be in bonded stores by October 1999, short term infrastructure (Plateau 0) support was identified. Plateau 0 was in place by August of 1995 and was mostly manual operations. The focus was the W76 and Manufacturing Development Engineering Projects. A Plateau 1 level was in place by the end of 1996. This level incorporated automatic operations where possible and was more integrated across the organization. Capabilities that Plateau 1 addressed included: Production Command Media, Document Management System, Calibration & Preventive Maintenance Scheduling System, Production and Certification System, Basic MRP and Purchase Orders with TXBASE, Product Data Management System, Inventory with TXBASE, and Supplier Quality Program. Plateau 2 Infrastructure was in place by 1999 and included implementation of Oracle.

Lean/Six Sigma

The impact of the lean/six sigma effort on the production culture was very significant. Once everyone accepted that waste was unacceptable and that six sigma was an objective for processes, a path forward was more easily defined. The elimination of waste was a concept that penetrated floor activities, infrastructure support, and research efforts. Striving for six sigma processes, or the level that is most appropriate for a specific process, established the need for fundamental understanding to define critical attributes and process control to assure the critical attributes are achieved.

Employee Safety Security Program

It was recognized that with production coming to SNL/NM, increased public awareness would occur should there be accidents on the production floor. An examination was made of existing programs at SNL/NM and also of programs that had been used at the PP. An Employee Safety Program (ESP) later modified to add security (ESSP), was established in August 1996. An existing successful program at the PP was used for the basic template. The program provides a "soft sell" environment for communicating and fostering a high level of awareness, interest and commitment for issues relating to ES&H and Security. The program is championed at the employee level with a manager sponsor. At the writing of this report, 60% of the eligible employees voluntarily participate in the program. The program includes contractors and collocated personnel from other organizations at SNL/NM.

The objective of the program is to develop a behavior-based safety culture consistent with SNL/NM's philosophy and commitment to an "injury-free culture." The program is an effective tool to build from the bottom up. Safe behavior is reinforced through visible recognition of the desired behavior. Coaching and education is provided for the employees. Safety/security standards and expectations are reinforced through communication. Upward feedback is encouraged. The program stimulates employee morale in a positive manner by offering a variety of incentives for participation. Safety and Security concerns addressed by the ESSP are not limited to workplace issues; a "safe/secure" mentality translates to all aspects of life, including home, auto, work and vacation. A safe environment is provided for employees to communicate sensitive issues to management without fear of reprisal.

There are five critical features of the ESSP program: picture of the month contest, department safety talks, seasonal contests, improved safety/security suggestions, and safety and security awards. In the monthly contest the workforce receives information on a safety/security topic through a web-based application. Hazards or security issues are identified. Relevant information is included and feedback is encouraged. For Department Safety/Security Talks, material is provided to the Management Team the first of each month. This material can be used by Managers in their Department meetings. This approach attempts to reach the 40% of the employees who do not participate voluntarily. Up to four seasonal contests are held to bring increased focus on specific safety/security issues. Employees are encouraged to identify hazards or security issues in the work environment through suggestions. The safety/security award provides recognition for employees caught doing the right thing.

ESSP Bucks are paper money credits issued to employees for their participation the program. One dollar is given for participation in the monthly contest. Five dollars are given for participation in the seasonal contests. Five dollars are given for safety/security suggestions, with an additional five dollars given if the suggestion is implemented. Five dollars are given to an employee who is observed by a co-worker to have corrected a safety hazard or to have eliminated a security issue. The nominating employee is sent a thank you email with a copy provided to his/her manager. The ESSP Bucks can be used to procure items from the ESSP Store, which contains items that are safety and/or security related. The cost of this program is about twenty dollars per employee per year. This program has helped to establish a culture of safety/security for employees, both at home and at work.

LESSONS LEARNED

As production of NGs was transitioned from the PP to SNL/NM, a number of lessons were learned. Some of the lessons learned are items that should be avoided if there is further down-sizing of the NWC. Other lessons learned are items that should be utilized during any further down-sizing of the NWC. Lessons learned within a generic theme are grouped together.

Production Capacity

In the Reconfiguration Project the design capacity for production of NGs at SNL/NM was 600 units a year. This level only supported the Active Stockpile and did not adequately support the Inactive Stockpile or development. In parallel with the Reconfiguration Project, a Rapid Reactivation Project was initiated to increase the production capacity from 600 units a year to approximately 1500 units a year. Not accurately specifying the capacity in advance resulted in increased cost and significantly increased risk to the Reconfiguration Project. Additional costs were incurred by the NWC outside of the Reconfiguration Project. Facility modifications, installation of equipment, and movement of production operations had to occur in parallel with qualification of processes and product for WR NTs and NGs. Further, adding increased capacity to buildings designed for low capacity crowded floor space and removed flexibility for future facility modifications that might be required to meet evolving production requirements.

The design capacity of a building needs to be accurately known before CDRs are finalized, and certainly before design and construction are begun.

Compliance to Regulations

Compliance-based Oversight

Most individuals responsible for compliance-based oversight within NNSA want projects to be successful, but NNSA personnel must assure that regulations and DOE Orders are followed. At times the approach of NNSA can appear to be orthogonal to the interests of SNL. These barriers must be addressed with NNSA personnel to define a path forward. Project leads who willingly consider the NNSA personnel as part of the team will have a more cooperative relationship. Information should be openly shared, in both directions, between NNSA and the project lead. Each party to the relationship must remember their own role and responsibility and respect the same for the others involved with the project. Privileged information must not be abused to give leverage to achieve specific objectives.

When a barrier is encountered that will preclude meeting the schedule, for example, it is preferred that the issue be communicated with a request for help in solving the issue. If the project is high priority and the priority has been previously agreed to, the author's experience is that a conscientious effort is expended to find a solution, even if it means implementing a non-standard approach that still complies with regulations. Performance issues should also be communicated, but timing must be considered. Since NNSA personnel responsible for oversight of a project cannot be excluded, it is more effective to proactively include them. Answer questions in a timely manner. The project lead must meet project commitments, or inform oversight personnel about the issue in advance. A successful project is in the best interest of both the project (SNL/NM) and NNSA.

Readiness Assessment

The RA process that was employed prior to 1995 was to complete the construction, equipment installation, and documentation before the formal assessment occurred. A week or two were required for the assessment process for a building the size of Building 870. Findings had to be addressed before start-up was permitted. This approach did not support the aggressive schedule of the Reconfiguration Project, so an alternate approach had to be developed. The existing approach was also lacking due to the concentration of time within two weeks to complete the formal assessment usually had severe schedule impacts on the participants and led to superficial examination of some processes. The potential existed for critical items to be missed.

Negotiations occurred with the SNL/NM and with NNSA personnel who were responsible for the assessment process to assure the combined needs would be met. A new process was defined wherein the assessment process could be completed in phases, category by category. The categories were: facility, NT fabrication processes, analytical measurements, NG fabrication processes, and tester activities. Findings found during one phase of the assessment were corrected while preparations were being made to assess a subsequent phase. This new approach worked very well, and has become the standard approach for RAs at SNL.

Based on our experience with this process during the Reconfiguration Project, it was suggested that the RA process could be improved even further. The facility assessment could be performed simultaneously with inspectors who performed the final walk thru at the end of construction. Rather than examining all of the equipment within a category, it was suggested that the assessment process could occur room by room. The RA of some buildings at SNL/NM whose construction was completed after Building 870 followed this new format. The Rapid Reactivation Project extended this concept even further where the assessment process was performed within the NG fabrication space in Building 857B one piece of equipment at a time. This later approach was required to support the movement of NG production activities from Building 870 to Building 857B with the constraint of qualifying a new NG simultaneously.

Another advantage of a phased RA is training. Findings identified in the first phase should not appear in subsequent phases, because participants have learned what to expect and how to prepare for an RA assessment. Further, decisions can be made as to the appropriate level of rigor for each phase. Either too much or too little leads to a less safe facility. Consideration can be given to the skill set of the assessors, and changes can be made if a different skill set would be advantageous for a specific phase. The assessment process should assure that the regulatory requirements are met. In general, it is not necessary to exceed the requirements.

Pressure Safety Documentation

When equipment was moved from the PP to SNL/NM, existing safety documentation at the PP was accepted at SNL/NM without further examination by SNL/NM Safety Engineers. At least in one instance, this was not a good decision. Pressure chambers with glass tops were put into use at SNL/NM. Several years later, one of the systems imploded, thankfully without injury to employees. During the analysis of the accident, it became clear that glass was not the preferred material for the top of the pressure system. One output from the root cause analysis of the accident was that the pressure safety of systems qualified at a location different than SNL/NM should not be accepted at SNL/NM without additional examination.

Development on Production Floor

When production of NGs was transferred from the PP to SNL/NM, the decision was made to complete development activities on the production floor. It was felt that the lower capacity demands would allow development and production to co-exist on the same floor with the same equipment. This would reduce facility and equipment costs significantly. Ultimately the efficacy of this decision was never fully tested, because higher capacity was required, and the Rapid Reactivation Project increased production capacities. Increased production demands clarified that development and production had diametrically opposite requirements and needed separate space and separate equipment to support the different requirements.

In hindsight, even if the required capacity had remained at about 600 units per year, putting development and production in the same space was not the best option. The demands of these two activities are orthogonal to each other. Development requires the flexibility to modify equipment and processes to complete experiments. Production resists taking equipment out of a qualified status. Optimization of production schedules through single piece part flow is disrupted by a development run whose schedule is uncertain and which may require dynamic adjustments during the experiment. Co-mingling these activities requires production to establish inventory prior to a development run which can be consumed during the development run while the equipment is not available. Equipment may need to be re-qualified after the development run to assure product meets requirements. Development can be held hostage by production delivery schedules, so development project objectives are seldom met and take more time than forecast. Uniform production throughput is disrupted when development projects are performed on production equipment.

In conclusion development and production need separate equipment, but as identical as practical, and separate floor space.

Design/Production Relationship Affected by Collocation

Under the umbrella of a single company and collocation at a single site, the relationship between design and production underwent a transformation. In the collocation model, design and production are held to common corporate goals and to common corporate metrics. The benefits of collocation were substantial, but required effort, time, leadership, and cultural transformation. The traditional hierarchy between design and production were no longer the same. A greater parity existed between design and production. Design no longer had to travel to observe production. Hence, the oversight was more easily accomplished and could be more detailed. Production no longer could prepare in a formal way for design visits. It was also much easier for production to push back earlier and with more influence on manufacturing issues. In general, the benefits outweigh the disadvantages.

When a fundamental model of interaction is changed, frustration and conflict are common outcomes. During the move of production from the PP to SNL/NM, the effects of collocation were not planned for. As a consequence, there was much frustration and conflict as issues were worked through. Roles and responsibilities had to be changed several times. As a consequence, the migration to the collocation model was less effective than it could have been.

Cost Comparisons

Trying to compare costs between a facility that has closed and a new production facility is approximate at best. Whenever the number of units produced decreases simultaneously, the comparisons become even more tenuous. Whenever the number of units manufactured on a production floor decreases, the cost per unit typically increases. Hence, one is trying to compare a lower manufacturing delivery capacity at the new location to what the costs would have been at the existing facility, and this becomes a virtual activity. Infrastructure costs are loaded differently at separate companies. These differences make it impossible to accurately compare unit costs.

Cost comparisons are further complicated when a new product line is introduced during the transfer of production activities. Increased yields could be due to the new product, could be due to a different approach to manufacturing, or a combination of both.

For these reasons, it is clear that a quantitative cost comparison of producing NGs at SNL/NM versus producing the same NGs at the PP is impossible. Even qualitative comparisons are tenuous. It is clear, however, when a facility is closed that infrastructure costs are decreased, at least, when the transferred infrastructure costs are relatively small compared to existing infrastructure costs at the new manufacturing site.

From a cost point of view, one would forecast that target loading at Los Alamos National Laboratory would be more expensive than target loading at SNL/NM. Experience verified a significant cost differential. The infrastructure required at Los Alamos National Laboratory to assure quality product was more expensive than the same quality oversight at SNL/NM. At SNL the oversight was a small addition to the infrastructure already in place for the other production processes utilized to manufacture NGs. At Los Alamos National Laboratory quality was a stand-alone activity. Further, there were costs associated with shipping of targets between the two sites.

Unused Production Floor Space

Building 870 and Building 857B were designed to accommodate equipment and assembly space to fabricate NTs and NGs. To reduce costs, unused production floor space was not allowed. This decision has a tendency to lock production operations into its existing manufacturing approach, because it is nearly impossible to dramatically modify existing space that must be maintained and continuously used for WR operations. During the Reconfiguration Project the benefit of single piece part flow and the elimination of process monuments were not envisioned. When there is no free production floor space, there is limited opportunity to continue WR production and simultaneously modify operations to accommodate a more efficient approach to production. Hence, some improvements cannot be implemented until a new building is constructed, which might be twenty to thirty years in the future.

Facility Construction

Relative to facility construction, a number of lessons learned occurred. These are discussed in the subsequent paragraphs.

Line Representative

The line representative for most facility construction projects at SNL are at too high of an organizational position. This compromises the ability for decisions to be made in a timely manner or it consumes excessive time on the part of the responsible manager. The success of the construction project is enhanced significantly if a Line Representative is selected who has a clear understanding of the project and the areas where decisions can be made by the Line Representative. It must be agreed in advance what decisions must be made at a management level above that of the Line Representative. Further, an arrangement should be made in advance as to when the Line Representative can have access to the decision maker, even if that is very early in the morning or late in the evening. As many decisions as possible should be pushed down to the Line Representative.

Regulatory Requirements

New construction will require a Checklist to be prepared and submitted to NNSA for a determination to be made relative to the level of regulatory documents that must be prepared. The determination can require nothing to be done, a Finding of No Significant Impact, an EA, an EIS, or documents associated with a nuclear facility. The preparation of these documents is on the critical path. Most of the documents are prepared under contract with NNSA, using SNL funds, and NNSA seldom has the same schedule requirements as SNL. Advanced planning for a new building can be started, but design completion can not be finished until the NEPA documents are in place. There are other authorization documents that need to be built into the project schedule.

Building Capability

A clear definition of the desired capability of the new construction must be completed early in the planning process. Building capability defines hazards, which must be known before a Checklist can be submitted to NNSA for NEPA determination. Further, the Checklist must be inclusive of hazards in the new building in comparison to hazards in existing space. Will the capabilities in the new building be new, an expansion of existing, or the movement of existing operations and hazards? This phase is usually completed at a high level early in a project, but with insufficient detail to support the Checklist submittal. Consequentially, too many construction projects need a rapid turn around of NEPA determination and the documents required by the NEPA determination, resulting in schedule difficulties.

Design Evaluations

As much as six to eight months can be removed from a new building construction schedule if a modified design evaluation can be negotiated with the SNL facility organization and the NNSA facility oversight personnel. Tight schedules may require this negotiation to occur. The typical approach is to temporarily stop the design process after the building is about 60% designed. An evaluation is made to assure the intent of the building is being met. This delay can approach a couple of months. The architectural design group is diverted to other projects. Later, the architectural group must come back up to speed on the project while responding to findings that surfaced during the evaluation. A similar delay occurs at the evaluation of the 100% design. These delays can be avoided if it is agreed in advance that design of the building will continue during the evaluation at the 60% completion. Findings are incorporated into the on-going design. The procurement package can be prepared during the 100% evaluation. Findings can be responded to before the construction package is released for bid in the private sector.

Funding and Timing of Funding

The source(s) of funding and the timing of when the funding will be required must be built into the overall project schedule. For Congressionally approved buildings, would a Continuing Resolution affect the project? If the construction phase should begin early in the fiscal year and if the project cannot accept a three to six month delay resulting from a Congressional Continuing Resolution, then the project must be planned so the construction phase begins in September or earlier. If the construction project is a GPP, how does the forecast schedule align with the fiscal year? Split year funding can result in the project being put on hold, if the funding at the beginning of a fiscal year is delayed. If the spending authorization is close to the maximum amount of funds allowed for GPP buildings, a delay could incur additional construction costs that might push the construction costs above that allowed for GPP buildings. If this occurred, the project would be immediately in violation of Congressional approvals with concomitant issues to resolve.

Chilled and Frozen Design

Before formal design occurs, a CDR should be prepared. During preparation of the CDR, a period of time must be allowed for dynamic changes as requirements are examined and adjacencies are developed. Mitigation of hazards must be addressed. Adjacencies and the overall design are rather fluid during the CDR stage. There must be a validation of the requirements, needed NEPA documentation, adjacencies, hazard mitigation, cost and schedule before formal design begins. The rather fluid condition that exists during CDR preparation migrates into a "chilled" and ultimately "frozen" status as the project moves into formal design. The higher the completion levels of the design, the more difficult and the greater the impact to cost and schedule changes become. After a design is frozen changes have a major impact on cost and schedule and must only be allowed for catastrophic issues discovered during the design. The occupant of the new building and the design team will work more effectively if these concepts are clearly understood and if "chilled and frozen" points are put into the schedule.

Building Modifications on the Production Floor

Facility modifications can be completed on the production floor without negative impact to yield or deliverables, if several things are done. Careful detailed planning must be completed to assure the path forward is achievable. The sequence for completing the work must be evaluated, with consideration given to each step and its potential impact on the quality of the product and on the production floor schedule both in the area of modification and other parts of the production line. Adjustments to the normal production flow must be agreed to, scheduled and monitored. Communication in advance and during each phase must occur with the production floor to identify and resolve issues that surface during the work.

Construction barriers should be put into place to control construction debris. Monitoring of adjacent surfaces for particulate contamination provides an indication when additional cleaning might be needed to maintain the level of cleanliness required to meet product quality requirements. Winter breaks should be used for major modifications that require significant stoppages to standard production work. Off-hours must be used when the scope of work can be completed within a sixteen-hour period of time and when the modifications are not compatible with the performance of regular work or when the work cannot be completed simultaneously with regular production work. After completing the work, the area is to be cleaned before and after removal of the construction barriers.

Legacy Testers and Stored Electronic Media

Many of the product testers that were transferred from the PP to SNL/NM, the Vanguard test data and the record of assembly management system, were obsolete. Because of the cost, time and impact to the Reconfiguration Project and the perceived impact to production schedules, updating the test capability and improving access to legacy electronic data were not completed during the transfer process. This led to an expensive and time-intensive effort to reestablish these obsolete capabilities after the first production units were placed into bonded stores. Limited resources (technical personnel and funds) during production further complicated fixing these issues. The legacy issues had not been fully resolved at the time this document was prepared.

The magnitude and importance of these issues were not recognized as the Reconfiguration Project was planned. Had the issues been addressed as part of the Reconfiguration Project, the total cost for resolution would have been less than fixing the issues over time. In any future consolidation effort within the NWC, these issues should receive more up-front consideration to determine the most cost and program effective approach to product testers and the retrieval of archived electronic data. Expediency and time consumption for completing the project must be balanced against total cost for resolving the issues over time.

Culture

One's culture is uniquely postured to produce the results of the organization. Defining the culture one wishes and implementing it many times brings frustration and failure, because the desired culture is foreign to what exists. Either overtly or subconsciously the existing culture resists and places barriers into the transition. The Organization must clearly understand the culture that exists and the culture that is required to achieve desired outcomes, particularly when the desired outcomes are significantly different than the output of the existing Organization. With this understanding plans can be developed and implemented to transition an organization from its existing culture to the preferred culture. A new culture must be grown. It cannot be specified, purchased, and implemented. The reasons for the culture change must be understood by all. It must also be understood that some may not be capable to make the adjustments, and an acceptable approach must be available for these individuals to leave the Organization.

Information Technologies

Utilization of existing infrastructure, in preference to development and maintenance of a stand-alone infrastructure, reduces the total cost to the organization of establishing a new or different production activity. Information Technologies is one area where giving up uniqueness and a little flexibility for standardization were cost effective for the Neutron Generator Production Organization. Establishing a partnership with Corporate Information Technologies brought many benefits to production. Production received more software with increased capabilities with less expense than had production established a stand-alone system. Using COTS software aided the implementation of commercial best business practices within production. Production's approach to Information Technologies is a feature that contributes to recognition of production at SNL/NM as a highly successful organization. This is one area where production became part of, and a contributor to, the larger organization, rather than to be an independent and isolated subset of the organization.

Project Management

The level of detail required for a project varies with the type of project. The detail required to bring a construction project back on track must include the daily activities of all of the subcontractors to allow for planning to resolve subcontractor interface logistic conflict and shortening of the critical path. In comparison, the detail for a research project is much less and might include decision points at critical parts of the project before certain activities are launched. The number of organizations involved in a project also affects the detail. Greater detail is required when multiple organization are involved, particularly when the oversight organization needs to be included. The detail helps to identify and resolve misunderstanding at the beginning of a project and helps to communicate the status during project implementation. Limited resources and criticality of cost control to complete the project within cost estimates drives the project plan to greater detail.

It is important that a project plan exist with sufficient detail to allow the project manager to monitor the project. Is the project on track, and if not, what is the item(s) causing the delay? The critical path and near critical path must be known to identify areas of productive focus. It does not help to remove several weeks or months from a task with extensive slack, unless the early completion frees resources that can be utilized on more critical tasks. The project manager might need to allow tasks with slack to slide so those resources can be used to address critical path or near critical path items. A project manager must have contingency in resources and funds to respond to unexpected events that will occur during any large project. Flexibility in resources and funds affects a manager's ability to shorten the critical path.

The Reconfiguration Project was large with many different parallel paths. The project was complex with oversight from DOE. There were activities initiated at SNL that had to integrate into the overall project plan. Hence, the approach to project leadership was rather extensive. A list of project leadership concepts utilized in this project is found in Appendix B.

Organization Issues

Knowledge and Experience Are Valued

The balance of knowledge and experience brought to SNL/NM for the production organization is an area that was identified and implemented very well in the Reconfiguration Project. Three different backgrounds were combined: production, research and development, and private industry. Though conflict existed, particularly when roles and responsibilities were not well defined, the experience and knowledge base of each group was valued and has contributed significantly to the successful culture established in production. Mixtures of these three groups existed at the management level and within the technical staff. Production floor operators were developed at SNL/NM under the direction of these three groups. As a result, the rigor required for production was maintained, but was influenced by those who appreciated technical understanding and those who focused on the bottom line. When these three groups came together and formed a culture different from all three, the uniqueness of production at SNL/NM was established. The bottom line is that if you want a dramatically different outcome, you must begin with a dramatically different mixture of knowledge and experience.

Roles and Responsibilities

When the PP was closed and production of NGs was moved to SNL/NM, too little effort was given initially to roles and responsibilities. The three major backgrounds (production, research and development, and private industry) each brought with it an implicit understanding of the roles and responsibilities of the different activities within the Production Organization, and the understanding was not the same within the different groups. The different perception of roles and responsibilities led to near chaos at first with unnecessary conflict. The organization recognized the importance of roles and responsibilities early in the production transfer activity; however, as the organization evolved roles and responsibilities had to be readdressed and modified to remain relevant to the needs of the organization. Having shared responsibility for a deliverable was inefficient and was the root of serious conflict. Implementation of lean/six sigma required the organization to restructure itself to realize the new approach. For these reasons, roles and responsibilities must be considered dynamic, not static. Changes must be made as required to keep pace with the evolving outcomes and the changing structure established to achieve those outcomes. Clear, common definitions and accurate communication are requisite for roles and responsibilities to be effective. The time must be taken to understand what is implied and that common words have a different meaning to those with different backgrounds.

Organization Structure

The adage, "an organization is perfectly structured to produce the results one observes," was found to be accurate for the Production Organization. When the Production Organization did not produce the desired output, the organizational structure was usually found to be a significant contributor. When a significantly different output was desired, a change in the organization structure was usually required. Hence, an organization must clearly understand what the desired outputs are. What objectives are to be achieved at what time and by whom? Is there a common understanding of the objectives and the implications of achieving the objectives? Does the responsible individual have sufficient resources to achieve the objective? Once these questions are clearly answered, the organizational structure must be examined. Doing things differently is nearly impossible, if the organizational structure does not change. Developing a responsive infrastructure, for example, will not occur with organizations designed and established to protect areas of responsibility and which have a hierarchy that does not integrate responsibility.

Flow Charting

By 1996 it was accepted that if a process could not be flowcharted, it could not be understood nor followed. This concept is valid for both physical processes and business practices. The process of flowcharting facilitates the establishment of a common understanding, identifies waste, accommodates assignment of responsibility, and fosters creativity for different approaches that simplify, reduce time, and/or improve yields. One cannot change what is not clearly understood. A common understanding will never exist when one or more individuals function from their backgrounds or perceptions without taking the time to assure there is a common understanding within the organization. Different words mean different things to different people, particularly when the people come from an intrinsically different culture. Hence, flowcharting is a technique that brings an organization to an agreement as to where the organization is, where it needs to go, and what are the steps that can be taken to reach the objectives. Flowcharting facilitates the assignment of responsibility with clear expectations. Everyone in the organization can visualize the process and what must be completed to improve it. Flowcharting also facilitated an integration of the specific process with other existing processes.

Production Command Media Hierarchy

When production was moved to SNL/NM, command media commensurate with a national laboratory was the initial basis for the production organization. The command media was driven by high level principles and flexibility with inadequate detail for production activities. The Production Organization overreacted to this condition. A command media hierarchy was developed that was overly descriptive and cumbersome to use. An attempt was made to collect external and internal requirements, which were used to define production policies, general procedures, operating procedures and records that were to be maintained. Over time it became clear that some documents existed, but were not followed. Other documents were never updated. The documentation hierarchy was so extensive that one could not understand, remember, or follow all of the requirements. Implementation of lean suggested that only the documents that added value should exist. Simplification occurred, and a more realistic compact set of command media and its hierarchy evolved. The command media hierarchy needs to be evaluated periodically to assure it is sufficient to demonstrate compliance to requirements, but that it also is not encumbered by non valued-added steps. Training must occur to assure everyone understands and follows the procedures contained within the command media.

CONCLUSIONS

The main purpose of closing the doors at the PP was to reduce costs within the NWC without loss of capability or reduction in quality of product. This objective was achieved. The cost savings in moving NG production to SNL/NM were realized primarily through the elimination of overhead and infrastructure expenses by closing the PP without adding significant overhead and infrastructure expenses at SNL/NM. The overhead cost of NG production at SNL/NM is very small compared to the overhead cost for other SNL mission expenses. Additional costs were saved through the implementation of a different approach to manufacturing, facilitated through the establishment of a production activity at a new location with contributions from personnel with a research background and by adding personnel with a commercial background.

Sandia National Laboratories was selected to manufacture NGs partially because the design for NGs occurs there. Hence, the technology was not new to SNL/NM. Key personnel were transferred from the PP. The combination of these two factors led directly to maintenance of capability to fabricate WR NGs within the NWC.

Collocation of design and production at a single site contributed to improved production performance. Manufacturability of designs received increased emphasis, and manufacturability issues surfaced earlier in the design to production transition. Production efficiency and process yields were improved. Collaboration of design and production to meet common corporate goals and metrics contributed to the improved performance. The collocation necessitated a different model of interaction between production and design. The relationship became less hierarchal and more of a partnership.

Adoption of lean/six sigma as the approach to manufacturing excellence led to improvements in process yields and elimination of waste. Relative to the start-up levels of production floor workers, the capacity of the production floor was almost doubled within three years without adding additional production operators on the floor. The separation of development and production into different space using separate but identical equipment eliminated conflict between diametrically opposite requirements and contributed to production success at SNL/NM.

The focus of the manufacturing activity at SNL/NM shifted from the start-up concept of batch processing to one of single piece part flow. The driver was the need for a responsive infrastructure and a more flexible manufacturing capability. A unique manufacturing organization exists, relative to other manufacturing organizations within the NWC, as a consequence of these efforts.

These improvements are a credit to the employees who pulled together to meet tight objectives (i.e. nearly impossible schedules and budget constraints). Regardless of these accomplishments, it is clear that facility and equipment design would have been different than what exists today, if the importance of agility and single piece part flow had been the focus during start-up activities. There would be fewer monuments and a more effective production process. The constraint of continuous fabrication of WR product and a limited budget, preclude making some modifications that would improve the efficiency of the production operations even more. Further, having no free space on the production floor limits changes that could be made to make the floor more effective.

APPENDIX A: DETAILED TIMELINE

Included in this Appendix is a detailed timeline for the Reconfiguration Project that begins in the late 1980's and ends early in 2005. The dates for the timeline were taken from formal and informal sources, complimented by memory of those involved. Some of the dates, therefore, could be off by a few months. This is not deemed critical because the primary purpose of the report is to capture the process, including items that were done well and things that should have been done differently, as a guide to others who might be faced with a similar task in the future. The overall timeline is accurate as to when the Reconfiguration Project began and was completed.

Reconfiguration Timeline		
Date	Event	Action/Consequence
Late 1980's	DOE identified future budget shortfall	Study ways to decrease budget
Spring 1991	Report issued on future budget shortfall	DOE should close production plants
Late June 1991	PP Pre-walk through by SNL personnel	SNL to determine if WR NGs could be Fabricated at SNL/NM
Early July 1991	SNL submitted response to DOE request	SNL would be able to fabricate WR NTs/NGs and would accept that mission assignment
Fall 1991	DOE asked if tritium target loading could be successfully performed at a site different than the WR fabrication plant	Tritium target loading can occur off-site from WR assembly plant without loss of quality or performance
Mid December 1991	Admiral Watkins announced tentative decision to close production plants and the preferred sites for new WR mission assignments	PP to close and SNL tentatively selected for mission assignment to fabricate WR NGs; SNL/NM to develop CDR to move WR fabrication of NGs to SNL/NM
January 1992	DOE defined plant capacity for NGs at SNL/NM to be 600 units a year	Critical input for CDR
January 1992	DOE indicated that production and development were to utilize the same equipment and the same floor space	Reconfiguration costs would be decreased; believed that impact to production and development would be low due to low total numbers of units to be fabricated
January 1992	Tritium target loading to be moved to Los Alamos	EIS avoided by moving tritium target loading to a Site with existing nuclear facilities
January to May 1992	CDR #1 for stand-alone facility at SNL/NM	Contract with Fluor Daniels paid for and managed by DOE
March to June 1992	CDR #2 for WR fabrication of NGs at Kansas City	DOE specified that existing plant facilities were to be modified and used
July to October 1992	CDR #3 for WR fabrication of NGs at SNL/NM--not to be stand-alone facility	DOE specified that existing buildings were to be modified, including Building 870, and other infrastructure was to be used

Summer 1992 to December 1992	NT prototyping to be moved from Building 891 to the East Annex of Building 870	NT prototyping was to be able to perform WR NT fabrication if decision was made to move mission assignment for NG fabrication from PP to SNL/NM; NT prototyping needed to be improved even if WR NG fabrication did not move to SNL/NM
Fall 1992	Formed two ES&H teams, one to support NT prototyping in East Annex of Building 870 and one to support WR fabrication of NGs in Building 870	ES&H input was received and addressed early in both projects assuring there would be no surprises with concomitant negative impacts to project schedules
October 1992 to August 1993	Continue CDR #3	Design time would be shortened, schedule issues were identified with work around, and preliminary exploration for selection of a design contractor would be completed
January 1993	New President from a different political party took office	Reconfiguration Project put on hold to allow assessment of cost savings and to allow new administration to evaluate Reconfiguration Project; CDR #3 to continue
Spring 1993 to October 1994	Activity Transfer Plan prepared	Described the transfer activity to move WR NG fabrication from the PP to SNL/NM; DOE and PP employees involved in preparation of plan
Spring 1993	Accident scenarios prepared for prototyping of NTs (encompassed WR fabrication of NTs)	Since NT prototyping was being moved to a new location within Technical Area I, it was prudent to determine if potential accidents would put the public or the environment at risk
June 1993 December 1994	Prepared SA for prototyping	This was a risk mitigation step. It was not believed that an SA was required; however, a decision in retrospect to require one would have had a large negative impact on the schedule
July 1993	DOE issued report indicating the new administration agreed that Reconfiguration was cost effective and should continue	This report opened the door for the Reconfiguration Project to be implemented
September 3, 1993	Authorization to implement Reconfiguration Project received	DOE moved mission to fabricate NGs from PP to SNL/NM; CDR #3 should be implemented
September 1993	Design contract for Building 870 released	An advance contract previously negotiated was implemented within the week of authorization; design time was shortened to 10 months
Fall 1993	List of critical skills developed	Critical skills required for WR fabrication of NGs were clearly stated; this list became the basis for identification of PP employees who should transfer to SNL/NM

Fall 1993	DOE agreed to design schedule changes for Title I and Title II	The changes reduced the design time by about 5 months, which recovered some of the time lost because of the hold placed on the project to evaluate the viability of the Reconfiguration Project
1993 to 1994	Non-tritium analysis support to be provided by Materials Science & Engineering Organization	Since existing infrastructure should be utilized, existing analysis capabilities at SNL/NM would not be duplicated by NG production with concomitant reduction in cost to Reconfiguration Project
1994 to 1995	Negotiations of infrastructure support from SNL Organizations	Existing infrastructure at SNL was not duplicated with concomitant reduction in Reconfiguration costs
Early 1994	Job description was prepared for each critical skill	The job descriptions were posted to allow interested PP employees to bid on critical skill jobs at SNL/NM
Spring 1994	Closure of PP moved up from end of September 1995 to end of September 1994	One year of operational costs were saved, length of Reconfiguration Project was not changed, and PP would be closed before new construction completed at SNL/NM, so needed location at SNL/NM to store equipment and to house employees who would be transferred
Spring 1994	Building 882 selected for storage of equipment shipped from PP	Occupants of Building 882 had to be moved out earlier than planned and demolition of Building 882 had to be delayed
Spring 1994 to Aug 1994	Four trailers (MO160, MO161, MO162 and MO163) were moved to a location across the street from Building 870	Office space was provided for about 40 employees who were transferred from the PP plant; SNL/NM managers and employees were also moved to the trailers to begin the integration
March and April, 1994	SNL/NM teams interviewed PP employees who bid on jobs and selected those who were most qualified	Individuals familiar with WR rigor were transferred to SNL/NM to assist in establishing capability at SNL/NM to fabricate WR NGs
Spring 1994	Value Engineering Study of Building 870	This shifted the design and construction of Building 870 from political factors to cost over the course of its life; the footprint exterior was straightened out and additional office space was added for minimal cost

Early Summer 1994	DOE announced that equipment that would help in the transition to private use of the PP would be left at the PP	Painful negotiation occurred as to what equipment would be left, Congress had to allocate additional funds to replace the equipment that was left, and SNL/NM had to procure $6 million of additional equipment and coordinate arrival within a tight schedule
August 1994 to October 1994	Building 879 was designed.	The design of an existing office building constructed with GPP funds was accepted for this building and the office space layout was changed to facilitate a teaming environment
September 1994	Construction of Building 870 began; construction to be completed by January 1996	Construction began in September so a Continuing Resolution in Congress would not impact the schedule
July 1994 to March 1996	Equipment procured and delivered to SNL/NM	Lead times for each piece of equipment had to be carefully negotiated and orders placed such that the equipment would not arrive before March 1996 nor after April 1996
October 1994 to September 1995	Shipment of WR production equipment from PP to SNL/NM	Once the last WR product crossed a piece of equipment, it was calibrated (when necessary), disconnected, packaged for shipment, and shipped to SNL/NM
Fall 1994	Staged new NT prototyping equipment in Building 882	Equipment to be installed in the East Annex of Building 870 was staged in Building 882 to minimize the time to bring prototyping of NTs on line
Fall 1994	Started SA for fabrication of NGs	As a risk mitigation step, even though it was not believed a requirement for non-nuclear and low hazard facilities, a SA was started for WR NG fabrication in Building 870
December 1994 to December 1995	Building 879 was constructed	Building 879 provided additional office space that facilitated teaming for employees within the Production Center
January 1995 to January 1996	Prototyping of NTs established in East Annex of Building 870	Once prototyping of NTs was established, the NT prototyping laboratory in Building 891 was decommissioned and process qualification of WR NT processes could begin while construction of Building 870 continued
January 1995 to December 1996	Established prototyping for NGs in Building 878	This jump-started the process of moving the fabrication of WR NGs (excluding NTs) to SNL/NM

February 1995	Construction of Building 870 behind schedule by almost 3 months	The completion date of the Reconfiguration Project was in jeopardy
March 1995	External construction expert brought into project	Critical path items were addressed (subcontractor interactions, Requests for Information, response to changes, etc.) with the goal to bring the project back on schedule
Spring 1995	DOE announced that the capacity of NG production needed to be about 1500 units a year	Building 870 did not have the equipment nor the space to achieve these higher capacity numbers
Spring 1995	DOE clarified requirements for non-nuclear, low hazard facilities	SA and ORR for Building 870 not required so SA for WR fabrication of NGs in Building 870 was stopped
Summer 1995	DOE clarified that RA for non-nuclear, low hazard facilities was responsibility of the building occupant	Modification of RA process became an internal to SNL activity with oversight and input from DOE, which allowed the process to change to a segmented process rather than a all-encompassing evaluation after all equipment had been installed
December 1995	Construction of Building 870 completed	The construction of Building 870 was completed ahead of schedule and within budget
Jan 1996 to Feb 1996	RA for Building 870 completed	The segmented schedule allowed areas of Building 870 to become operational while equipment was still being installed in other areas of the building, which was necessary to support qualification activities. The segmented approach for RA completion has become a standard at SNL
January 1996 to December 1996	NT prototyping laboratory in Building 891 decommissioned	Removed tritium operation from the center of a highly populated research building in the center of Tech Area I and made space available for other activities
1996	Building 700, Phase I designed	The Production Center would have flexibility space to stage new production equipment and to evaluate different production processes off the production floor
March 1996	72 employees and significant SNL partners were moved into the office space in Building 870	Technical staff and technicians were collocated in the building where qualification efforts had Begun
May 1996	RA for NT processing completed	Qualification efforts for the WR NT line began
June 1996	RA for analytical testing completed	Qualification efforts for analytical testing began, with initial emphasis on the WR NT line

October 1996	RA for testers completed	Qualification efforts for tester began for both the NT and the NG production lines
December 1996	RA for NG processing completed	Qualification efforts for the WR NG line began
Feb 1996 to Dec 1996	Equipment installed in Building 870	Equipment transferred from the PP and new equipment were installed and could be operated safely, supporting WR qualification efforts
August 1996	ESP implemented	A low-key, bottom up program encouraged employees to be aware of the environment and to apply safe working approaches; the program subsequently incorporated security (becoming ESSP)
January 1997	Rapid Reactivation Project submitted again	Rapid Reactivation Project was postponed. Permission received to re-examine the initial CDR for increased capacity
1997	Building 700, Phase I constructed	This provided flexibility space to stage production equipment and to evaluate potential processes for production off the production floor, and ultimately, to support development work for NTs
March 1997	DOE accepted Building 870 for use	The RA document and the new RA process had been accepted by DOE. Building 870 could be used for its intended purpose
October 1997 to April 1998	Rapid Reactivation Project revisited, no lapse in WR fabrication could occur	Could not make ventilation modifications without shutting down the WR NG production line in Building 870; hence, Building 857B would have to be constructed
April, 1998	NEPA checklist submitted for Rapid Reactivation Project	Necessary to determine the level of NEPA documentation required for the Rapid Reactivation Project
Summer 1998	EA required for Rapid Reactivation Project	DOE determined that an EA would be required, primarily because of the new construction of Building 857B
Summer 1998	NT production line WR qualified	WR NTs could be fabricated.
August 1998 to January 1999	EA for Rapid Reactivation Project (Building 857B) completed	EA can take up to a year and only 4 months were available if the project was to start on time. DOE agreed the project was required and expedited the EA process. The start date of the Rapid Reactivation Project was delayed until February, so the project started as a Red project

February 1999	Rapid Reactivation Project began	This project began during final qualification of NG production line and would greatly impact the WR NT production line
February 1999 to November 1999	Building 857B was designed	Space more realistic with the WR production activities for NGs was made available and SNL/NM did not have to force-fit NG fabrication into space already too small
February 1999 to December 1999	Modifications were designed and completed in Building 870 to increase capacity of NT production line	The Production Center had the equipment and space required to increase the production capacity of the NT production line to support a 1500 a year NG level
Spring 1999	NG production line WR qualified	WR NGs could be manufactured with confidence that design specification would be met
Summer 1999	Reliability tests for NGs (23 tests with no failures)	Successful completion of tests demonstrated NG product fabricated at SNL/NM met reliability requirements
August 1999	WR NGs put into bonded storage	Reconfiguration Project completed on time and WR NGs were in bonded stores ready for shipment
January 2000	Construction phase of Building 857B shortened to 10 months; completion date scheduled for Jan 2001	Response to EA being released late, with the intent to keep the Rapid Reactivation Project on its original schedule
March 2000 to December 2000	Construction of Building 857B	In August of 2000, construction of Building 857B was accelerated to accommodate movement of WR NG production in Building 870 to building 857B line over the Winter Break, successfully implemented
December 2000 to March 2001	Move WR production line for NGs from Building 870 to Building 857B and qualify line in Building 857B	Two thirds of the NG production line was moved over the Winter Break and qualification began in January. The balance of the NG production line was moved in January and the entire line was qualified by March in Building 857B
April, 2000	MC4368A qualified	Early completion of Building 857B contributed to SNL successfully qualifying the MC4368A in less than 12 months, a timeframe not previously experienced
Spring 2001	Burning platform identified	The equipment and floor space existed to support a capacity of 1500 NGs a year, but the number of employees on roll could only support about 700 NGs a year

November 2001	Lean six sigma selected	Lean six sigma selected as management approach to reduce waste and concurrently to improve production efficiency to increase production capacity without increasing the number of floor operators
March to October of 2002	Design of Phase II of Building 700	This was the first step is being able to remove NG development from production floor space and equipment
December 2002 to August 2003	Construction of Phase II of Building 700	Completion of construction of Building 700 began the process to separate development from production equipment and floor space for NGs
January 2003	NT prototyping performed in Building 700	For NTs this capability in Building 700 allowed a separation between development and production activities
Spring 2003	Production Center reorganized into Product Value Streams and Support Departments	Production Center organized to align the management structure to the selected approach of lean six sigma; organizations given control over resources required to be successful
January 2004	NG prototyping performed in Building 700, not on production floor	With the completion of construction of Phase II of Building 700, development for NGs was performed off the production floor
Early in 2005	Single shift capacity increased to 1000 units a year	Through lean and six sigma efforts the single shift capacity was increased from 700 to 1000 NGs a Year

APPENDIX B: PROJECT/PROGRAM LEADERSHIP PRINCIPLES

The author was asked to include in this report a summary of the approach to project leadership utilized during the movement of production of NGs from PP to SNL/NM. The material is included within this Appendix, because it is not an integral part of the relocation of production from the PP to SNL/NM. The information is provided in a bullet format. Not all bullets would be applicable to every project, and not all aspects of this list were utilized for each part of effort to move production of NGs to SNL/NM.

Project/Program Concepts

- Ownership: The project lead must take ownership for the project, even if the issue was not of the lead's making.
- Complete Picture: A complete picture of the project/program is needed with its relationship to other activities that affect or are affected by the project/program.
- Schedule, Cost and Performance: The priority among schedule, cost and performance must be understood; all three of these cannot have equal and top priority. One can shorten schedules if resources are available or if greater risk can be absorbed.
- Project Plan Perspective: The project plan is a tool and not necessarily the required procedure that controls all aspects of the project. Be prepared to modify or to set parts of the plan aside, if that helps complete the task within the constraints of cost, schedule and performance.
- Detail of Project Plan: The tighter the schedule, the greater the complexity, the more significant the output, and the presence of political consequences drive the project plan to more detail and more careful monitoring.
- Correct Set of Participants: Insure that the correct set of individuals, based on skills and/or responsibility, are involved in the evaluation and decision process.
- Expectations: Clearly understand expectations before the project begins. Refine the expectations periodically during the project to assure hidden agendas are identified and responded to.
- Milestones: Significant and critical milestones must be established to allow the lead to monitor the health of the project.
- Critical Path: One must know the elements of the critical path. Emphasis should be directed towards shortening or eliminating critical path elements. This is where the bulk of the time is spent.
- Near Critical Path: One must know equally well the near critical path items. Success in shortening the critical path shifts near critical path items into the critical path. Almost the same attention is directed here as to critical path items.
- Items with Slack: Be prepared to let items with slack miss target completion dates as long as they won't become critical or near critical. Yet, in general, all items should be completed to the schedule.
- Monitoring: Areas that must be tracked should have a schedule and expectations set up in advance so participants anticipate and prepare for monitoring. Absence of a schedule suggests

the project manager is micromanaging or second-guessing, or even worse that the project lead is checking up on them because the project lead does not trust them to complete the item on time or to the quality needed for the project.

- Oversight: Include individuals who are responsible for oversight in relevant aspects of the project. If you don't obtain their buy-in during the project, you will have to deal with their comments during assessments or after the project is finished.
- External Approval: Items that require approval from outside of the project must be managed carefully. External coordination requires time (slack). Very careful coordination and advanced negotiation are requisite if a required approval is on the critical path.
- Delegate: Sub element leads must have significant responsibilities delegated to them. Clear responsibilities must be communicated so they understand their space. The interrelationships among the subsets of elements must be understood so subject matter experts and subset leads know how their element impacts others.
- Empowerment: The project lead and sub element leads should be empowered, based on experience, demonstrated good judgment, and skill basis. Drive decisions down to the extent practical. When all decisions have to be presented to a responsible manager outside of project implementation, time is lost in getting together and the project lead or sub element lead is disenfranchised.
- Trust: The lead must trust the subject matter experts to deliver. Check points need to be built into the project to help the lead identify those who need coaching or assistance. Some might not have the skill set required to finish the task. Encourage others to ask for assistance.
- Share Success: Do not take credit for the tasks completed by another. Share credit with the contributors in person and in group presentations.
- Help Others Look Good: When your management and SNL/NM receives positive press regarding your project, it greatly simplifies obtaining support and help if difficulties are encountered. If you let them help you, you will not have to tolerate them controlling you.
- Share the Consequences: When something goes wrong, share the impacts with those who contributed to the issue, but don't focus on the one who made the decision. If you do, you will lose credibility and support from others that are involved. Accept part of the responsibility yourself. As a minimum the issue was not anticipated.
- Communication: The amount of communication depends on the circumstances. The lead should understand what information others need to complete their responsibility and to properly represent the project. Interest level is another factor to consider. Too much detail takes time to prepare and additional time for the recipient to read, leading to lack of attention to the critical aspects of the project. It also sends a message of lack of confidence. Insufficient detail slows the project down and contributes to missing the cost or schedule targets.
- Challenges: Be open about problems and challenges that will surface during the project. Let others help address and solve the challenges.
- Confront Obstacles: The lead must be prepared to confront obstacles whether they be procedural or a member of the team.
- Ask for Help: Don't hesitate to ask for help or clarification. Too many feel this indicates to managers an inability to manage the project. Questions might be taken as an indication of poor performance. Requesting help or clarification indicates you have an understanding of others' skill set and a willingness to have others contribute. Sometimes, a manager due to position, skill set, or experience can facilitate something much more expeditiously than the project lead.

- Ask Why: When one is told it either cannot be done or cannot be done that way, the lead must ask why. Be open to alternative options. Do not accept barriers without exploring if different options exist.
- Brainstorm: One must be willing to explore options out of the box with an open mind to assure the best path forward is identified and fairly evaluated. Complete this phase before final decisions are made.
- Share the Challenge: Most individuals rise to a challenge. Let others that are affected by the project know of the difficulties (challenges and opportunities) and provide a vehicle for them to contribute to the solution.
- Replace or Reassign: Be prepared to replace or reassign participants who don't have the skill set, the time, or the interest to complete their assignments.
- Fix It Later: Sometimes it is more effective to rectify an element later than to put an entire project on hold to fix it now.
- Anticipate: The lead must anticipate external events that might influence the project. Those outside the lead's control must be planned for to not have unexpected delays. An example would a Congressional Continuing Resolution that might stop a project from beginning at the start of a new fiscal year.
- Implement versus Delay: If it is unknown if an activity will be required, but there will be insufficient time to implement and complete the task once its requirement is known, the project lead must be willing to expend resources to implement the task. Not implementing the task could result in a missed schedule. Once the decision is made, the item either continues or is killed. If schedule is the lowest priority among cost, performance and schedule, the task would not be implemented, but it must be clearly understood by everyone that schedule may be in jeopardy.
- Decision Making: Schedule-driven projects may require decisions to be made before all of the data is available that one would want. No decision is actually a decision to postpone the decision. Yet, premature decisions can be catastrophic. Balance is needed between timely decisions and waiting for additional information. The balance among cost, performance and schedule must be considered.
- Don't Cry Wolf: Never tell anyone that something is critical and then allow the information or parts to not be collected commensurate with the urgency communicated, otherwise, credibility will be lost.
- Focus: Focus on the event or issue, never on the person.
- Can-do Attitude: The lead must have a positive attitude and must communicate a belief that all issues can be resolved. An open mind is required to obtain the best solution to an issue. Much of the motivation for a project comes from the lead.
- Enthusiasm: Others are energized by the lead's enthusiasm. Most of the team will follow the lead's behavior.

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